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SEASONAL POND NATURAL AREA MANAGEMENT PLAN

COLONIAL NATIONAL HISTORICAL PARK

Prepared for:
National Park Service
Colonial National Historical Park
P.O. Box 210
Yorktown, Virginia 23690

Prepared by:
Virginia Department of Conservation and Recreation
Division of Natural Heritage
Natural Heritage Technical Report 04-05
July 2005

DCR
Department of Conservation & Recreation
CONSERVING VIRGINIA'S NATURAL & RECREATIONAL RESOURCES

NATIONAL PARK SERVICE

SEASONAL POND NATURAL AREA MANAGEMENT PLAN

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SIGNATURE PAGE

SEASONAL POND NATURAL AREA MANAGEMENT PLAN

COLONIAL NATIONAL HISTORICAL PARK

July 2005

Recommended by: Charles Rafkind — 10/20/05
Natural Resource Manager — Date

Recommended by: Tom Nash — 10/20/05
Chief Ranger — Date

Approved by: Alec Gould — 11/04/05
Superintendent, Colonial NHP — Date

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Various current and former DCR-Division of Natural Heritage (DNH) staff contributed to the development of this Plan. Tom Rawinski's "*Vegetation Ecology of the Grafton Ponds, York County, Virginia*" provided the basis for plant community classifications. DNH Ecologist Gary Fleming performed an analysis of over 1,500 coastal plain vegetation plots to give the most current classification of natural communities associated with seasonal pond occurrences at COLO. Nancy Van Alstine, Anne Chazal, and Kathleen McCoy authored "*A Biological Survey of the Coastal Plain Depression Ponds (Sinkholes) of Colonial National Historical Park, Yorktown, Virginia*", which provided current biological and ecological information for the COLO seasonal ponds. Kenn Clark authored the "*Grafton Ponds Natural Area Preserve Resource Management Plan*" which provided background information, a conceptual ecological model, and recommendations for managing natural heritage resources associated with seasonal ponds within the Grafton Ponds Complex. Chris Hobson contributed pertinent zoological information, participated in a key site visit in March 2003, and provided review comments on the draft management plan. Nancy Van Alstine supplied color photographs depicting COLO seasonal ponds and their biota and also provided review comments on the draft plan. Finally, Pat Jarrell assisted by managing financial affairs and handling administrative tasks.

PLAN SUMMARY

The purpose of this Management Plan is to guide stewardship of natural resources associated with seasonal ponds located within Colonial National Historical Park (COLO). Management actions are needed to protect existing resources and to restore human-altered habitats. The objective of this Plan is to provide a sound basis for managing seasonal pond resources with a focus on the natural communities and rare biota associated with seasonal ponds at COLO. This objective is tied to the goal of enhancing conservation of the Park's overall biological diversity. Seasonal ponds are one of Virginia's rarest and most threatened wetland types. COLO ponds are part of a larger, nationally significant system of seasonal ponds known as the Grafton Ponds Complex. At the landscape level, this extensive concentration of seasonal ponds provides habitat for at least seven species of rare plants and animals and represents critical breeding habitat for regionally uncommon amphibians, odonates, and other invertebrates.

The primary objectives of seasonal pond natural area management are:

- maintenance or enhancement of environmental conditions required to perpetuate rare species and natural communities and,
- restoration of lost or diminished ecosystem functions. By taking actions such as controlling invasive species, restoring hydrological processes, and reinstating natural disturbance regimes the National Park Service (NPS) can restore habitat conditions for rare species and also restore natural communities associated with seasonal ponds at COLO.

A Natural Heritage inventory of the seasonal ponds at COLO was completed in 2001. This work involved detailed ground-based surveys of features previously identified and mapped from aerial photographs as "possible sinkholes". The Natural Heritage inventory confirmed seasonal pond occurrences and yielded abundant biological and ecological information about these habitats at COLO. Twelve seasonal ponds are now known to occur at COLO, lying on the northwest margin of the Grafton Ponds Complex and just south of the Village of Yorktown. Many of the monitoring and management recommendations within this Management Plan are an outgrowth of the previous inventory study. Seasonal ponds at COLO provide habitat or represent potential habitat for a variety of rare and declining animals and plants. While some are currently in a degraded condition, COLO's seasonal ponds nevertheless represent one of the Park's most significant natural resources, containing important elements of biodiversity and holding high potential for habitat restoration.

This plan delineates five non-contiguous management units, each comprising a separate component of the Seasonal Pond Natural Area within COLO. Information is summarized about physical and biological features associated with and affecting management needs within each unit. Specific management issues are identified and recommendations are given regarding monitoring and management actions required to perpetuate, enhance, and restore occurrences of natural heritage resources associated with seasonal ponds at COLO. Key monitoring and management recommendations include:

- Invasive species monitoring and control – especially for Japanese stilt-grass;
- Restoration of forested seasonal pond habitat in Unit 3 through natural succession;
- Determining the extent and effects of deer browse on vegetation of seasonal ponds and associated habitats;
- Preventing damage from incompatible public uses within or adjacent to seasonal pond wetlands such as trail construction, unauthorized mountain bike use, and repeated foot traffic;
- Maintaining hydrologic balance and water quality by monitoring and mitigating negative effects from adjacent neighborhoods and roadways;
- Determine the effects of long-term fire exclusion on the biota associated with seasonal pond habitats, developing fire management plans that provide for controlled burning to benefit seasonal pond habitats, and if feasible, implementing a prescribed burn program;
- Develop interpretive and other educational programs that provide information to the visiting public as well as adjacent private landowners about the presence and importance of seasonal ponds at COLO.

This Plan:
1. Provides an overview of the physical and biological setting for seasonal ponds within COLO;

2. Describes rare species and natural communities present at COLO as well as those present in similar habitats on adjacent lands of the Grafton Plain;

3. Delineates and describes five management units containing seasonal pond habitats at COLO;

4. Provides monitoring and management recommendations for conserving resources associated with seasonal pond habitats on the Grafton Plain in Virginia.

INTRODUCTION

Along with its well known historic and cultural resources, Colonial National Historic Park (COLO) supports significant natural resources in the form of marsh, estuarine, field, forest, and shoreline habitats. Notably, the Yorktown Unit of COLO contains seasonal ponds lying to the south and southeast of the Village of Yorktown. These ponds are part of the Grafton Ponds Complex that continues south of COLO and constitutes the best remaining example in Virginia of a Coastal Plain Seasonal Pond Complex.

The area of low, level topographic relief south of Yorktown known as the Grafton Plain is characterized by shallow depressions formed from dissolution and collapse of shell-rich layers in underlying marine sediments. These depressions accumulate and hold water during the winter and spring, and in some years standing water persists well into the summer months. These ephemeral water bodies have been given various names: vernal pools, coastal plain depression ponds, sinkhole ponds, depressional wetlands, and seasonal ponds. In this Management Plan, the term *seasonal pond* is used throughout to describe the ponds themselves. The primary vegetative association that characterizes this wetland type is known as the *Coastal Plain Depression Wetland* natural community (Fleming et al. 2004).

The Grafton Ponds Complex consists of more than 200 seasonal ponds across the Grafton Plain supporting at least seven species of rare plants and animals plus significant natural community occurrences. Ponds and adjacent uplands also provide habitat for numerous regionally uncommon amphibians, odonates (dragonflies and damselflies), and other invertebrates. Perhaps most significantly, seasonal ponds are, typically, fishless wetlands. The absence of fish predators makes seasonal ponds prime and vital breeding grounds for many amphibians – a diverse group of animals widely believed to be experiencing general population declines over much of the globe. Protection and management of seasonal pond habitats at COLO, as well as on adjacent state- and locality-owned lands, has great potential to maintain these important breeding sites, conserving populations of many different species of amphibians as well as other wetland-associated species.

Previous Natural Heritage Inventory of COLO Seasonal Ponds

In 1998, the Virginia Department of Conservation and Recreation's Division of Natural Heritage (DCR-DNH) began a two-year study of the ecology and biota of seasonal pond habitats at COLO (Van Alstine et al. 2001). The study involved detailed ground-based evaluations of 35 terrain features mapped by staff at the College of William and Mary's Virginia Institute of Marine Science (VIMS) using early 1990's orthophotos (Berman et al. 1996). In that study, features were identified as "possible sinkholes" ostensibly supporting seasonal ponds and associated natural communities. During 1999 and 2000, these mapped features were systematically located on the ground and surveyed by DCR-DNH staff to determine if seasonal ponds occurred at the mapped locations and, if so, to collect detailed biological and ecological information. This "ground-truthing" revealed that six of the mapped features were, in fact, forested seasonal ponds supporting fauna and flora characteristic of Coastal Plain Depression Wetlands – a significant and declining natural community in Virginia (Fleming et al. 2004). Another six seasonal ponds were confirmed in an open field setting (COLO Field 10) where an annual mowing regime has

for many years maintained herbaceous vegetation in an open, non-forested condition. For each pond location, data were collected describing vegetative community composition and structure, rare plant and animal occurrences, common plants and animals, soils, and invasive plant species present.

Seasonal Pond Management Plan

In 2001, DCR-DNH began work on this Management Plan for the Seasonal Pond Natural Area at COLO. The objective of the Plan is to provide a sound basis for managing seasonal pond resources with a focus on the natural communities and rare biota associated with seasonal ponds at COLO. This objective is tied to the goal of enhancing conservation of the Park's overall biological diversity. Seasonal ponds are one of Virginia's rarest and most threatened wetland types. COLO ponds are part of a larger, nationally significant system of seasonal ponds known as the Grafton Ponds Complex. At the landscape level, this extensive concentration of seasonal ponds provides habitat for at least seven species of rare plants and animals and represents critical breeding habitat for regionally uncommon amphibians, odonates, and other invertebrates.

This Plan:

1. Provides an overview of the physical and biological setting for seasonal ponds within COLO;

2. Describes rare species and natural communities present at COLO as well as those present in similar habitats on adjacent lands of the Grafton Plain;

3. Delineates and describes five management units containing seasonal pond habitats at COLO;

4. Provides monitoring and management recommendations for conserving resources associated with seasonal pond habitats on the Grafton Plain in Virginia.

GENERAL PARK ENVIRONMENTAL, BIOLOGY AND PHYSICAL RESOURCE BACKGROUND

Description and Location

The Park is located on Virginia's Lower Peninsula midway between Richmond and Norfolk (Figure 1). COLO covers over 8676 acres and extends from Jamestown through Williamsburg to Yorktown, flanked on the north by over 31 miles of the York River and to the south by the James River. The primary components of COLO are the Jamestown and Yorktown Units, connected by the Colonial Parkway and its associated corridor of open space (Figure 2).

Climate

Virginia's Lower Peninsula – that land area lying southeast of Richmond between the York and James Rivers – experiences hot, humid summers and cool, wet winters. Mean annual temperature is 58°F with a mean January temperature of about 40°F and mean July temperature of about 78°F (Hodges et al. 1985). The average daily maximum temperature in July is 88°F and the average daily minimum in January is 28°F. Annual precipitation averages around 47 inches, but is less than 40 inches about every two years in ten and more than 55 inches about every two years in ten. Precipitation is well-distributed throughout the year with slightly more than half the average annual total rainfall (55%) falling during the six-month period from April through September. The growing season (days between last and first freezing temperatures) averages 175 days and ranges up to 217 days (Hodges et al. 1985). The last frost occurs in mid- to late-April and first frost occurs in mid- to late-October. Prevailing winds are from the southwest with average speed of 10 miles per hour (NOAA 1993). Relative humidity averages 78% annually, with lowest humidity readings occurring daily in early afternoon with an annual average low of 57% (NOAA 1993).

The Lower Peninsula is subject to strong cyclonic wind storms: hurricanes, ~~tropical storms,~~ and "nor'easters". Nor'easters are the most frequent of these and occur in autumn, winter, and spring. Tropical storms, including hurricanes, are less frequent than nor'easters and occur during the period June through November. Strong thunderstorms are also common and occur between late spring and early fall (Hodges et al. 1985). Each of these storm types can cause sudden, sometimes drastic changes to forest vegetation which in turn can influence other processes including shallow groundwater infiltration, the local soil water balance, potential for and types of wildfires, invasive species spread, and patterns of natural succession. Notably, on September 18, 2004, Hurricane Isabel influenced the forests of eastern Virginia and, in particular, caused extensive wind throw of larger trees at COLO. While not a canopy replacement event, Isabel created numerous single- and multiple-tree canopy gaps plus extensive exposure of mineral soil in the form of tip-mounds from wind thrown trees.

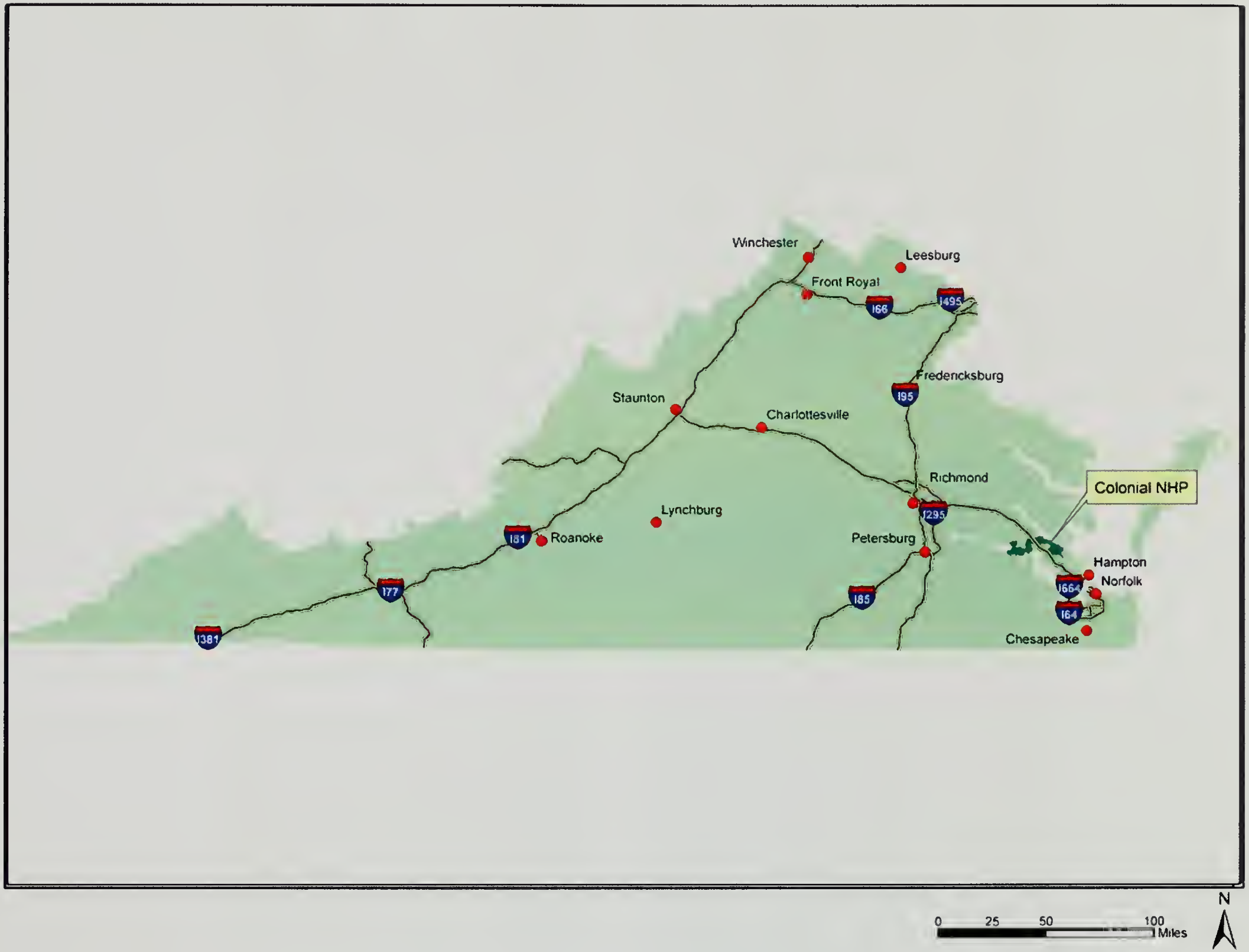

Figure 1. Location of Colonial National Historical Park in Virginia

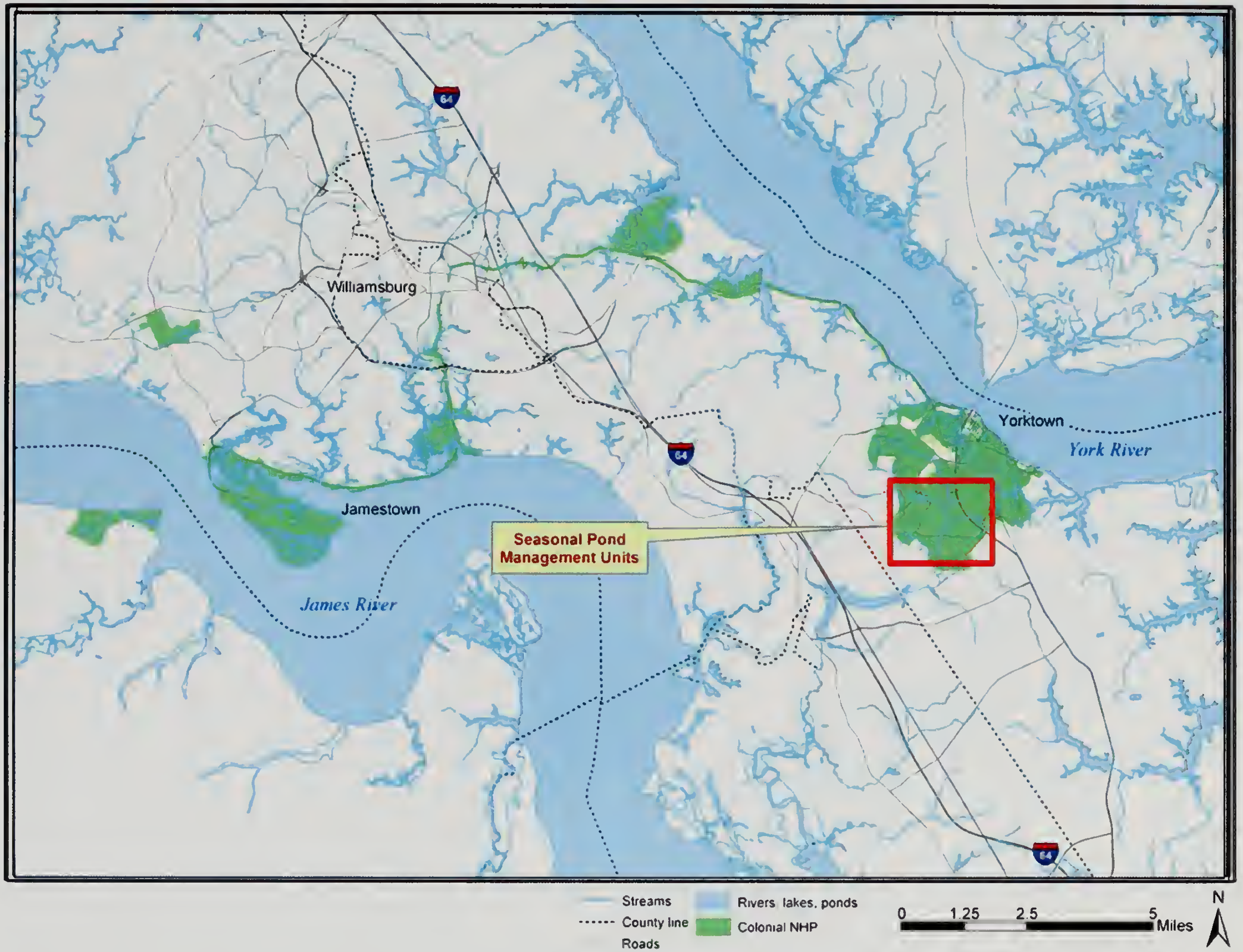

Figure 2. Regional map showing Colonial National Historical Park in reference to the James and York Rivers, Yorktown, the City of Williamsburg, and Interstate 64.

Landforms, Geology, and Soils

Landforms. Virginia is comprised of two major landscape units of the North American Continent: the Atlantic Coastal Plain and the Appalachian Highlands. The Atlantic Coastal Plain unit is represented in Virginia by the Coastal Plain Province and the Continental Shelf (Woodward and Hoffman 1991). COLO lies within the Coastal Plain Province, geologically characterized by layers of unconsolidated sediments (sands, gravels, clays) eroded from the Appalachian highlands to the west and deposited over crystalline bedrock (Fenneman 1938; Dietrich 1970).

A portion of COLO occurs on that part of the Atlantic Coastal Plain called the Grafton Plain (Johnson 1972), a mostly flat area bounded on the northwest by the Lee Hall scarp, on the east by the Suffolk scarp, and on the south by the Kingsmill scarp. The Grafton Plain is characterized by numerous shallow depressions, many containing seasonal ponds (Johnson 1972). Geomorphically, these depressions are thought to be up to 100,000 years in age (Johnson et al. 1993). Pond elevations on the Grafton Plain range from 40 to 70 ft above mean sea level.

Geology. The Grafton Plain is underlain by the Chuckatuck formation (Johnson et al. 1993), formerly mapped as the Windsor formation (Johnson 1972). The Chuckatuck is from 20 to 30 feet in thickness consisting of layered marine and estuarine silts and sands. Beneath the Chuckatuck is the Yorktown formation, composed of shelly marine sands and clays about 60 feet thick with interbedded deposits of marine mollusk fossils. The shell-rich nature of the Yorktown is key to an explanation of why seasonal ponds are present in this portion of coastal Virginia.

Ponds on the Grafton Plain develop in surface depressions caused by dissolution of the underlying carbonate-rich Yorktown formation and subsequent subsidence of overlying marine sediments (Johnson 1972). Level topographic relief impedes runoff; thus, most precipitation percolates downward through underlying sediments. As water reaches the shell-rich layers, calcium is dissolved from the shells into groundwater as calcium carbonate, which is carried away in solution. Over many years, enough calcium and other soluble minerals are removed to cause shallow surface depressions to form, due to subsidence of the overlying strata and soil material. Surface depressions hold water to varying degrees. Those underlain by clay have relatively slow percolation rates, yielding "perched" water tables and resulting in longer periods of standing water. Depressions also trap and accumulate organic matter that further retards percolation rates and increases water retention periods (Clark 1998).

Soils. Soils on the Grafton Plain are predominantly of the Bethera, Izagora, and Slagle series. These are deep, mostly clay or loam soils ranging from poorly drained to moderately well drained. In general, these soils are nearly level to gently sloping, situated on flats and in depressions on uplands (Hodges et al. 1985).

Bethera series. Bethera soils are deep, nearly level, and poorly drained located on upland flats and in depressions. They formed in acid, clayey fluvial and marine sediments. Slopes range from 0 to 2 percent. The surface layer is silt loam about 7 inches thick. The subsurface layer extends to a depth of more than 65 inches consisting of gray clay loam, silty clay loam, and clay. Permeability is slow and surface runoff is very slow or ponded. A seasonal high water table is 1

foot (or more) above the surface to 1.5 feet below the surface during the winter and spring (Hodges et al. 1985). Seasonal ponds at COLO are most often associated with Bethera soils.

Izagora series. Izagora soils are deep, nearly level, and moderately well drained on broad upland flats. They formed in acid, loamy and clayey fluvial and marine sediments. Slopes range from 0 to 3 percent. The surface layer is dark gray loam about 4 inches thick. The subsurface layer is light brown loam about 9 inches thick and the loamy to clay loam to clay subsoil extends to a depth of at least 78 inches. Permeability is moderate in the upper portion of the subsoil and slow in the lower part. Surface runoff is slow and a high water table is present at a depth of 2 to 3 feet in winter and early spring (Hodges et al. 1985). Izagora soils are located on those better-drained areas on relative uplands surrounding and between seasonal ponds.

Slagle series. Slagle soils are deep, nearly level and moderately well-drained on upland terraces, on broad flat uplands, in slight depressions, and are often associated with side slopes of small drainageways. They formed in loamy and clayey fluvial and marine sediments. Slopes range from 0 to 6 percent. The surface layer is dark grayish fine sandy loam about 4 inches thick. The subsurface layer is light brown fine sandy loam about 5 inches thick. The subsoil extends to a depth of 50 inches, consisting of mottled yellowish brown clay loam and sandy clay loam. Permeability is moderate to moderately slow. Surface runoff is slow, and a high perched water table is present at a depth of 1.5 to 3 feet in winter and spring (Hodges et al. 1985).

Hydrology

The Columbia Aquifer underlying the Grafton Plain is unconfined and recharged locally through infiltration of precipitation. Water in the Columbia moves laterally to points of discharge (springs, seeps, streambeds, marshes, York River) and also vertically to deeper aquifers. The Columbia occurs in the Chuckatuck formation and is the most influential aquifer on water levels in seasonal ponds at COLO and elsewhere in the Grafton Ponds Complex. Seasonal pond water level and hydroperiod varies with shallow aquifer depth, precipitation amounts, soil saturation, and evaporation and transpiration rates (Speiran and Hughes 2001).

In most years, depressional wetlands on the Grafton Plain do not hold standing water year round (Rawinski 1997) – hence the name “seasonal ponds.” Ponds often start to fill in late fall or early winter (December-January) when evapotranspiration reaches an annual low. Ponds reach maximum depth in March, and are usually dry by the end of July. However, a great deal of variation is associated with this pattern both among ponds and between years. Rawinski (1997) observed that during a relatively dry year (1995), many ponds were dry by June and some ponds had not filled at all. In the following relatively wet year (1996), some ponds retained water through the entire year.

Water depths for selected ponds at COLO were recorded on three dates between May 2000 and June 2002 (Table 1). These results provide a simple demonstration of both the within-year and between-year variation in water depth of seasonal ponds on the Grafton Plain. Water levels in ponds are controlled by a combination of precipitation, evapotranspiration, surface inflow, and groundwater inflow and outflow. The variation in both depth and persistence of water in ponds can be, in part, explained by topographic variation and the position of the pond relative to the groundwater flow system.

Table 1. Variation in water depth of selected Colonial National Historical Park seasonal ponds.

	Date of Measurement		
Pond Number	May 9, 2000	August 11, 2000	June 17, 2002
1	50 cm	25 cm	0 cm
9	24 cm	9 cm	0 cm
11	34 cm	15 cm	*
12	52 cm	15 cm	*

* Water depth not recorded

Area Land Use History

At the time of initial European exploration and settlement (late 1500's – early 1600's), Chiskiack Native Americans occupied the area that is now York County, Virginia (Hansford 1972). For the most part, Native Americans living in coastal Virginia at this time lived in small settlements, cultivating small areas of land for corn and other plants and also hunting and gathering for subsistence. These native people used fire routinely for various purposes: land clearing for agricultural use, driving game, warfare, and to increase production of fruit-bearing plants such as blueberries (Whitney 1994). While the precise effects of fire on the landscape and biota on the presettlement Lower Peninsula are unclear, it is both likely and generally accepted that periodic fires maintained open habitat niches where herbaceous plants and associated fauna persisted.

Around 1630, European settlement of the area that was to become York County began in earnest with settlers coming both from Jamestown to the west and from Europe (Hansford 1972). Water was the primary means of transportation during this time and settlements began along the James, York, and Poquoson Rivers (Hopkins 1942). Many large plantations were established during the 1600s. Tobacco was the cash crop and a large basis of the colonial economy (Hansford 1972). Large-scale land clearing by settlers to provide both farmland and timber began to significantly alter the landscape by the late 17th century (Whitney 1994).

Yorktown became a busy port in the 1700s and settlements in the area expanded. The late 1700s brought the American Revolution and its associated transportation improvements including road construction and creek dredging to improve navigation. The final battle of the American Revolution was fought at Yorktown in 1781 (Hansford 1972). The War of 1812 and the Civil War followed in the 1800s, bringing further expansion, more roads, and railroads.

During the 1900s, the center portion of the Lower Peninsula maintained much of its rural character, with agricultural uses declining and many thousands of acres of abandoned farm land reverting to forest through natural succession. Active land management for forest products became a common land use, supported by the presence of a pulp and paper mill northwest of COLO in the town of West Point. Several military bases were established or expanded during World Wars I and II, and today numerous military installations remain as key land use features of this region. Two major urban areas expanded greatly during the 20th century on both ends of the Peninsula: Richmond on the northwest and Hampton/Newport News to the southeast.

Because of its location between expanding metropolitan areas and the presence of an interstate highway (I-64) along its entire spine, the Lower Peninsula is experiencing rapid development. The urban interface is advancing quickly into the rural countryside to the west of the cities of Hampton and Newport News. The level uplands of the Grafton Plain in York County, long dominated by forest and agricultural land uses, are being developed for suburbs, shopping centers, and associated intensive land uses. The area is increasingly fragmented by new roads and subdivisions. Groundwater withdrawals for domestic and industrial use are affecting groundwater supplies in ways only now becoming appreciated and understood. Much of the land adjacent to the Yorktown Unit of COLO is currently in use for residential housing. Other areas e owned by the U.S. Navy, U.S. Coast Guard, and the City of Newport News for watershed protection, recreation, wildlife habitat, and other forest uses. By 1985, only a small proportion (14 percent) of the Lower Peninsula remained in agricultural use (Hodges et al. 1985), and today (2005) this proportion is even smaller. Military reservations continue to occupy a significant portion of the landscape and represent notable undeveloped open space in the vicinity of COLO.

Grafton Ponds Natural Area Preserve (NAP) is located just southeast of COLO (Figure 1). This 374-acre tract is owned by the City of Newport News and was dedicated as a State Natural Area Preserve in 1995. DCR-DNH cooperatively manages the preserve with Newport News for the primary objective of protecting and perpetuating its natural heritage resources – in particular, rare species and natural communities associated with seasonal ponds.

An important and emerging aspect of wetland resource management on the increasingly urban Grafton Plain is the relationship between suburban residents and mosquitoes. Of particular concern is the issue of mosquitoes as disease vectors and the public demand for control programs. With the emergence of West Nile Virus (WNV) as a significant human health threat, landowners including state and federal governments are increasingly aware that wetland resources under their stewardship are perceived as potential sources of disease-carrying mosquitoes. Expanded mosquito control programs on the Lower Peninsula have increased potential to conflict with other resource management objectives as residential land use advances into previously rural portions of the Grafton Plain and its complex of seasonal ponds.

General Vegetation Summary

Vegetation at COLO is a mosaic of mixed pine-hardwood upland forests, lowland forests and wetlands, tidal marshes, and open grassy fields. Fields have been maintained by NPS using mowing programs in order to preserve the open appearance and character of portions of this historic landscape. Much of COLO is forested by second growth upland pine-hardwood forest. Some of these forests originated as successional old fields abandoned following the Civil War and largely undisturbed since then. Some older upland forest areas contain large oaks, yellow-poplar, and loblolly pines – many of exceptional height and diameter.

In general, the better drained forested areas within COLO support white oak (*Quercus alba)*, black oak (*Q. velutina*), loblolly pine (*Pinus taeda*), southern red oak (*Q. falcata*), yellow-poplar (*Liriodendron tulipifera*), American holly (*Ilex opaca*), and various hickories (*Carya* spp.) as dominant tree species (Sankey and Schwenneker 1993; Rawinski 1997). More poorly drained forested areas are dominated by red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), and

sweetgum (*Liquidambar styraciflua*). Loblolly pine is the most common forest conifer and is present across the soil moisture gradient.

Natural Processes

A long-term process influencing development of seasonal wetland communities at COLO is groundwater dissolution of carbonate-rich materials in the Yorktown formation and ensuing surface subsidence, allowing formation of characteristic shallow ponds. A key year-to-year process affecting the biota in seasonal pond habitats is evapotranspiration, in direct association with annual and seasonal variation in precipitation amounts. Natural disturbances to vegetation greatly influence habitat development, since they can either partially or completely remove the forest overstory as well as the subcanopy and groundcover layers. Disturbance types include tree diseases, insect infestations, severe droughts, ice storms, strong wind storms, infrequent high intensity wildfires, and more frequent low intensity wildfires. The latter – frequent surface fires – would have characterized the presettlement period and would have once functioned to moderate forest floor development, maintain a more open understory, and promote herbaceous abundance and diversity in the groundcover layer.

Since canopy openness directly influences herbaceous species abundance and composition in and adjacent to seasonal ponds situated in forest settings, tree growth rate – in particular lateral canopy encroachment into pond openings following canopy removal – is another process that affects groundcover vegetative composition. Recurring fires, including those that occurred following and in combination with canopy-removal events such as severe ice storms and hurricanes, would have once functioned to keep seasonal ponds and surrounding forest habitat continuously open by retarding woody plant development. The forest floor would have been less well developed and groundcover layer would have been less dominated by woody plants and more herbaceous in nature. The dense understory that characterizes much of the Grafton Plain today would have been much less apparent and lacking in many locations. Such maintenance of seasonal pond habitats in a more open historic landscape context would explain the present existence of the last vestiges of rare herbaceous plant populations having an affinity for full sunlight. This historic role of fire in combination with the period of fire exclusion during recent decades also provides an explanation for the current rarity of species such as Harper's fimbristylis (*Fimbristylis perpusilla*) and Cuthbert's turtlehead (*Chelone cuthbertii*), both requiring the unusual habitat conditions of seasonal pond hydrology and an absence of shading from adjacent vegetation.

The recent (September 18, 2004) visit of Hurricane Isabel to southeast Virginia, with its tropical storm force winds following a record-setting wet growing season, resulted in extensive blowdown of larger sized trees over much of the eastern half of the state. In particular, the forests at COLO and the surrounding area experienced frequent (although unquantified at this writing) wind throw within forested habitats. Along with possible implications for predisposing COLO forests to fire, the implications of Hurricane Isabel as a disturbance event may be most significant from the standpoint of invasive species management. Japanese stilt-grass (*Microstegium vimineum*), along with some other problem species, will likely increase as a result of the increase in its favored invasion sites: partial-sunlight, exposed mineral soil, in this case on wind thrown "tip-ups" or tree root systems. The storm also caused large increases in quantities of

downed coarse woody debris which, among other functions, serves as important habitat for herpetofauna and invertebrates.

Legal Considerations

Laws generally governing National Park management. The most important statutory directive for the National Park Service is provided by interrelated provisions of the NPS Organic Act of 1916, and the NPS General Authorities Act of 1970, including amendments to the latter law enacted in 1978. The key management-related provision of the Organic Act is: [The National Park Service] shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified... by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations. (16 USC 1)

Congress supplemented and clarified these provisions through enactment of the General Authorities Act in 1970, and again through enactment of a 1978 amendment to that law (the “Redwood amendment,” contained in a bill expanding Redwood National Park, which added the last two sentences in the following provision). The key part of that act, as amended, is: Congress declares that the national park system, which began with establishment of Yellowstone National Park in 1872, has since grown to include superlative natural, historic, and recreation areas in every major region of the United States, its territories and island possessions; that these areas, though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage; that, individually and collectively, these areas derive increased national dignity and recognition of their superlative environmental quality through their inclusion jointly with each other in one national park system preserved and managed for the benefit and inspiration of all the people of the United States; and that it is the purpose of this Act to include all such areas in the System and to clarify the authorities applicable to the system. Congress further reaffirms, declares, and directs that the promotion and regulation of the various areas of the National Park System.

Other laws. Many natural resource laws pertain to the management of rare species, wetlands, and natural communities in Virginia (see Appendix C). Among these are the Federal Endangered Species Act (16 USC 1531 - 1544), the National Environmental Policy Act (42 USC sections 4321 - 4307d), the Virginia Endangered Species Act (Code of Virginia sections 29.1-230 - 237), the Virginia Endangered Plant and Insect Species Act (Code of Virginia sections 3.1-1020 - 1030), the Virginia Wetlands Act (Code of Virginia section 28.2-1300 - 1320), and the Virginia Environmental Quality Act (Code of Virginia sections 10.1-1200 - 1221).

The Virginia Endangered Plant and Insect Species Act, The Federal Endangered Species Act, and the Virginia Endangered Species Act pertain to species that are listed or are proposed to be listed as threatened or endangered at the state or federal level, and provide protection measures for listed species. The Federal Clean Water Act pertains to protection of wetland communities. The National Environmental Policy Act and the Virginia Environmental Quality Act require environmental review of certain projects proposed, funded, or authorized by state or federal agencies or institutions.

SEASONAL POND NATURAL AREA OVERVIEW

Natural Areas Management

Management actions are needed on natural areas for many reasons; among them, to return human-altered land or vegetation to a condition that supports continued existence of rare species and/or natural communities by reinstating required processes or by abating stresses. The primary objectives of natural areas management are restoration of ecosystem functions and maintenance of environmental conditions required to perpetuate rare species and natural communities. Actions such as invasive species control, restoration of natural hydrological conditions, or introduction of fire through controlled burning can improve habitats for rare species and maintain the integrity of many natural communities.

Resource management plan for Colonial National Historical Park. A Resource Management Plan (RMP) has been developed for COLO (NPS 1993) to provide direction and establish priorities for the protection and preservation of both cultural and natural resources within the park. The RMP functions as a broad action plan, which defines resource management issues and describes what management, monitoring, or research actions are needed to restore damaged resources, mitigate current adverse impacts, and protect sensitive resources from current or future threats. Additional natural and cultural resource management goals include:

- Protecting rare, threatened, and endangered species as a part of the naturally evolving ecosystem;
- Restoring, protecting, and preserving natural watershed conditions and processes, and native plant and animal communities that are characteristic of the Coastal Plain;
- Achieving a more thorough understanding of cultural and natural processes through research and monitoring in order to guide management activities and interpretation;
- Providing excellent interpretation, environmental education, and outreach programs to foster public understanding, appreciation, involvement and support;
- Developing and maintaining cooperative protection strategies with federal, state and local government agencies, community groups, corporations, and individuals to protect the integrity of the natural and cultural environments within and surrounding the park;
- Developing, operating, and maintaining park facilities in a sustainable manner; and;
- Conducting park operations in a way that minimizes impacts to natural and cultural resources.

NPS management policies for restoration of natural systems. NPS policy states that the NPS will re-establish natural functions and processes in human-disturbed components of natural systems in parks unless otherwise directed by Congress. These impacts to natural systems resulting from human disturbances include the introduction of exotic species; the contamination of air, water, and soil; changes to hydrologic patterns and sediment transport; the acceleration of erosion and sedimentation; and the disruption of natural processes. NPS will seek to return human-disturbed areas to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated. NPS will use the best available technology, within available resources, to restore the biological and physical components of these systems,

accelerating both their recovery and the recovery of landscape and biological-community structure and function. Efforts may include, for example:

- Removal of exotic species;
- Restoration of areas disturbed by NPS administrative, management, or development activities (such as hazard tree removal, construction, or sand and gravel extraction) or by public use;
- Restoration of natural soundscapes; and
- Restoration of native plants and animals.

Seasonal Pond Numbering System

Each seasonal pond identified within the Seasonal Pond Natural Area at COLO has been assigned an identifying number within the 1 – 12 sequence. Previously-used (Berman et al. 1996; Van Alstine et al. 2001) identifying numbers for COLO seasonal ponds are provided in the following crosswalk (Table 2).

Table 2. Crosswalk of seasonal pond numbering sequences used in current and previous studies of ponds within the COLO Seasonal Pond Natural Area.

Management unit number (name)	New pond number	Previous pond number
1 (Crawford Road Pond)	1	15
2 (Tour Road Swamp Pond)	2	46
3 (Tour Road Field Ponds)	3	44
	4	42
	5	43
	6	45
	7	47
	8	48
4 (Earthwork Ponds)	9	55a+b
	10	55c
5 (Siege Lane Ponds)	11	62
	12	63

General Seasonal Pond Natural Area Description

Five management units have been delineated which together comprise the Seasonal Pond Natural Area at COLO covering a total of 218 acres (88 hectares). Twelve seasonal ponds of various size occur in these five units, all within the Yorktown Unit of COLO. Six seasonal ponds are within forested areas while six others are presently situated in an open field maintained by mowing. Two management units (1 and 2) contain one pond each, while three units (3, 4, and 5) contain

multiple ponds. Units are either sufficiently distant from one another, and/or have unique management issues so as to be delineated and considered individually from a management perspective (Figure 3).

Forested ponds. Four management units (1, 2, 4, 5) support a total of six seasonal ponds within a context of forest vegetation. Seasonal ponds numbered 1, 2, 9, 10, 11, and 12 are located within these four units. Upland forest vegetation surrounding seasonal ponds in all four units is similar and generally classified as Mixed Oak/Heath Forest (Fleming et al. 2001). Common canopy species include white oak (*Quercus alba*), southern red oak (*Quercus falcata*), loblolly pine (*Pinus taeda*), scarlet oak (*Quercus coccinea*), and yellow-poplar (*Liriodendron tulipifera*). Red maple (*Acer rubrum*), flowering dogwood (*Cornus florida*), and black gum (*Nyssa sylvatica*) are typical subcanopy species. The groundcover is sparse, with blueberry (*Vaccinium* spp.) and huckleberry (*Gaylussacia* spp.) contributing the most significant cover. Herbaceous plants include Christmas fern (*Polystichum acrostichoides*), striped wintergreen (*Chimaphila maculata*), and partridge-berry (*Mitchella repens*).

Vegetation within forested seasonal ponds on the Grafton Plain has been classified by Rawinski (1997). The two predominant seasonal pond vegetation associations are: (1) Loblolly Pine – Willow Oak / American Holly / Slender Spikegrass, and (2) Sweetgum – Swamp Black Gum / Cypress-swamp Sedge. Fluctuating water levels create multiple zones and micro-habitats within and around ponds and pond margins, resulting in more than one association at some ponds.

Forested ponds at COLO support a relatively low diversity of herbaceous plants, with species composition similar to that in many other ponds of the Grafton Complex (Rawinski 1997). Woody plants include sweet gum, red maple, black gum, loblolly pine, willow oak, pawpaw, highbush blueberry, and fetterbush. While swamp black gum (*Nyssa biflora*) is known from many ponds in the Grafton Complex, it has not been found in COLO ponds. Cypress-swamp sedge (*Carex joorii*) is the most common herb in the Grafton Ponds Complex and is present in all forested ponds at COLO. None of the eight rare plants documented by Rawinski (1997) within the Grafton Ponds Complex have to date been found in COLO ponds.

Field ponds. Six seasonal ponds occur in an open field condition within Unit 3 (ponds numbered 3, 4, 5, 6, 7, and 8). The field containing these ponds lies to the north of Tour Road (COLO Field 10) and dates to the Colonial Period when the original forest was cleared for agricultural uses. For nearly four centuries, succession to forest vegetation has been prevented by tillage, grazing, haying, and, more recently under NPS management, by mowing in order to preserve the historic landscape. The six seasonal ponds in this open field condition support a contrasting flora to the six forested ponds. Tall flat panic grass (*Panicum rigidulum*), smartweeds (*Polygonum* spp.), and rushes (*Juncus* spp.) are prominent. Two watchlist (S3) plant species (big carpet grass, slender spikerush), occur in these herb-dominated wetlands. Exotic plants – some considered invasive – are present and common, but summer and fall flora are composed predominantly of native species. High species richness and greater herbaceous biomass relative to forested seasonal ponds results from increased light and low competition in these open, mowed habitats.

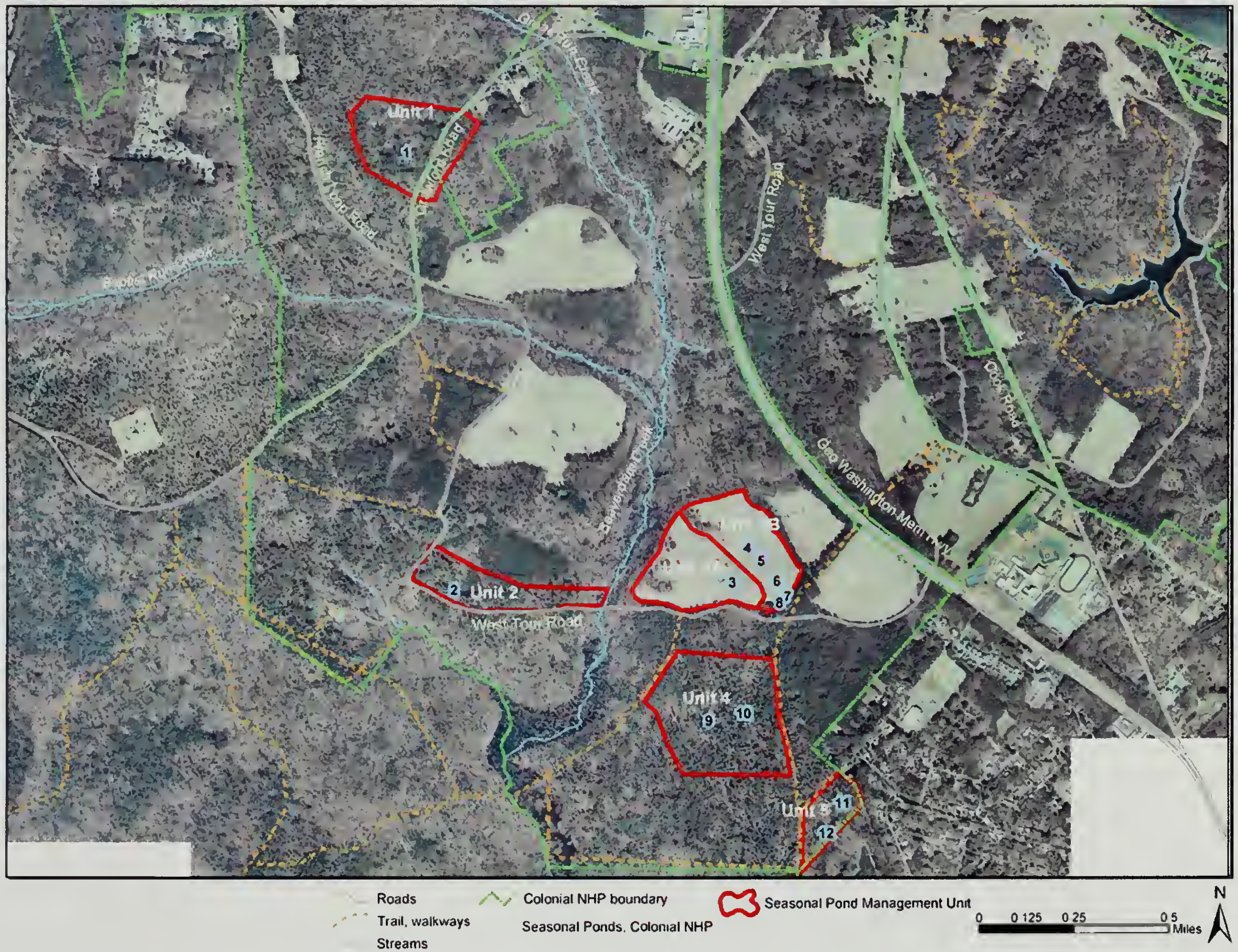

Figure 3. Location of five management units and their associated ponds comprising the Seasonal Ponds Natural Area at Colonial National Historical Park.

Natural Heritage Resources

Natural heritage resources (NHRs) are defined in the Natural Area Preserves Act (Code of Virginia, section 10.1-209) as: "*...the habitat of rare, threatened, or endangered plant and animal species, rare or state significant natural communities or geologic sites, and similar features of scientific interest benefiting the welfare of the citizens of the Commonwealth.*" NHRs are the most likely natural resources to be lost without conservation action in the near future. DCR-DNH compiles current listings and location information for NHRs within Virginia.

NHRs monitored by DCR-DNH are termed *elements* of natural diversity. Each element is assigned a rank that indicates its relative rarity on a five-point scale (1 = extremely rare; 5 = abundant). Ranks are assigned both in terms of the element's rarity within Virginia (State or S-rank) and over its entire range (Global or G-rank). G- and S-ranks help direct conservation actions to the rarest species and communities since these are the most vulnerable to extinction. Species or communities assigned a ranks of S1 or S2 are considered to be *state-rare.* A rank of S3 indicates a species or community is uncommon and vulnerable to extirpation in Virginia, but is too abundant to be designated as "rare". Elements assigned a rank of S3 are listed separately on a *watchlist*, meaning their status is watched carefully since decreases in abundance could signal an increased risk of extirpation (see Appendix B).

Locations that support significant occurrences of NHRs are delineated as "conservation sites", with the level of ecological significance represented using a *biodiversity rank* (B-rank). The B-rank summarizes the rarity, quality, condition, viability, defensibility, and variety of all element occurrences on a site. B-ranks are used to prioritize and direct conservation actions to sites with the highest quality occurrences of rare plants, animals, and natural communities (Appendix B). B-ranks range from B1-B5, with B1 assigned to the most ecologically significant sites and B5 describing sites where elements occur but with relatively low ecological significance.

Seasonal pond complex. The key NHR of the Yorktown Unit at COLO is the Coastal Plain Seasonal Pond Complex. The term "complex" indicates an extensive landscape area encompassing numerous surface depressions containing seasonal ponds, as well as rare natural community types associated with the ponds. The seasonal pond complex on the Grafton Plain consists of more than 200 depressional wetlands, twelve of which are now known to occur within COLO. Approximately 70 seasonal ponds of varying sizes are located within the adjacent Grafton Ponds Natural Area Preserve owned by the City of Newport News. Seasonal ponds in the Grafton Complex range in diameter from 30 to 300 feet and vary in maximum depth from 0.5 to 5.25 feet (Rawinski 1997). Most ponds are circular to elliptical, but some have irregular shapes possibly due to the joining of adjacent ponds. Most ponds become dry during the summer and fall of most years. The majority of ponds in the Grafton Complex are forested wetlands; however, some are open (emergent) wetlands lacking a forest canopy. With the absence of fire as a disturbance factor in recent decades, emergent wetland vegetation in and around seasonal ponds is maintained by activities such as rights-of-way maintenance and mowing to maintain hayfields and pastureland.

Typical tree species in forested ponds include red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), and black gum (*Nyssa sylvatica*). Other tree species present within COLO ponds are

loblolly pine (*Pinus taeda*), willow oak (*Quercus phellos*), overcup oak (*Q. lyrata*), and laurel oak (*Q. laurifolia*). Common shrubs include highbush blueberry (*Vaccinium corymbosum, V. formosum*) and fetterbush (*Leucothoe racemosa*). Common herbaceous plants in forested ponds include cypress-swamp sedge (*Carex joorii*). In the COLO field ponds, herbs including tall flat panic grass (*Panicum rigidulum*), smartweeds (*Polygonum* spp.), and rushes (*Juncus* spp.) are dominant (Van Alstine et al. 2001).

The Grafton Ponds Complex is home to a significant invertebrate and herpetofauna. Aquatic insects are common invertebrate residents of the ponds. The best represented groups include the true bugs (Heteroptera), beetles (Coleoptera), and dragonflies (Odonata) (Roble 1998). The dragonfly fauna has been extensively studied, with common species including fragile forktail (*Ischnura posita*), painted skimmer (*Libellula semifasciata*), swamp darner (*Epiaeschna heros*), southern common spreadwing (*Lestes disjunctus australis*), and eastern pondhawk (*Erythemis simplicicollis*). While not currently known from ponds at COLO, at least one seasonal pond on the Grafton Plain harbors a state watchlist (S3) damselfly, the duckweed firetail (*Telebasis byersi*) and a state watchlist dragonfly, the comet darter (*Anax longipes*) (Clark 1998). One watchlist damselfly, *Enallagma daeckii*, has also been reported from one COLO seasonal pond (Van Alstine et al. 2001).

The most common amphibian species of the Grafton Complex include southern leopard frogs (*Rana sphenocephala*), northern cricket frogs (*Acris crepitans*), marbled salamanders (*Ambystoma opacum*), and chorus frogs (*Pseudacris ferriarum, P. triseriata*) (Roble 1998). Common reptiles include spotted turtles (*Clemmys guttata*), eastern mud turtles (*Kinosternon subrubrum*), and eastern box turtles (*Terrapene carolina carolina*). The state-listed (threatened) Mabee's salamander (*Ambystoma mabeei*) is known from one of the two seasonal ponds within Management Unit 3 (Van Alstine et al. 2001). The state-rare (G5S2?) southern chorus frog (*Pseudacris nigrita*) was discovered in 2003 at Pond 12 within Unit 5 (pers. comm.. C. Hobson 2004) (BIOTICS 2004).

Metapopulation ecology. Metapopulations are sets of partially isolated populations belonging to the same species. Different populations can exchange individuals and recolonize sites in which the species has recently become extinct. Metapopulation ecology provides a useful framework for understanding the dynamics of fragmented populations in heterogeneous landscapes, and how these populations might respond to future perturbations such as climate change. Seasonal ponds are good examples of isolated habitats supporting wetland-dependant species existing in metapopulation. On the Grafton Plain, most rare species associated with seasonal ponds are likely members of spatially separated but genetically similar members of metapopulations, connected by various pathways and processes. This concept may be key to developing successful management strategies for restoring diminished species occurrences.

Rare natural communities. A *natural community* is an assemblage of co-existing, interacting species, considered together with the physical environment and associated ecological processes that usually recurs on the landscape (Fleming et al. 2001). Natural communities are those that have experienced only minimal human alteration or that have recovered from anthropogenic disturbance under mostly natural regimes of species interaction and disturbance. Seasonal ponds at COLO support several occurrences of two rare community types, both within the Coastal Plain

Depression Wetland ecological community group (Fleming et al. 2004). These rare natural communities are (1) Loblolly Pine – Willow Oak / American Holly / Slender Spikegrass and (2) Sweetgum – Swamp Black Gum / Cypress-Swamp Sedge. National Vegetation Classification (NVC) community synonyms are provided below (Table 3).

Table 3. Rare natural communities associated with seasonal ponds at Colonial National Historical Park.

Ecological Community Group	Community Type	Global Rank	State Rank	Legal Status
Coastal Plain Depression Wetland	Loblolly Pine-Willow Oak / American Holly / Slender Spikegrass NVC synonym: *Liquidambar – Acer rubrum – Quercus phellos / Leucothoe racemosa* Forest [CEGL006110]	G?	S1	none
Coastal Plain Depression Wetland	Sweetgum-Swamp Black Gum / Cypress-Swamp Sedge NVC synonym: *Liquidambar styraciflua – Acer rubrum – Nyssa biflora / Carex joorii* Association [CEGL06223]	G1G2	S1	none

<u>Loblolly Pine – Willow Oak / American Holly / Slender Spikegrass Type</u>. This community type occurs on drier margins of the wetland vegetation and grades into the surrounding mixed oak/heath forest and is synonymous with the National Vegetation Classification (NVC) name: *Liquidambar styraciflua – Acer rubrum - Quercus phellos / Leucothoe racemosa* Forest. This type is present at all four of the forested COLO seasonal pond management units (Units 1, 2, 4, and 5). In addition to the nominal *Pinus taeda, Quercus phellos, Ilex opaca,* and *Chasmanthium laxum,* characteristic species include red maple (*Acer rubrum*), persimmon (*Diospyros virginiana*), pawpaw (*Asimina triloba*), sourwood (*Oxydendrum arboreum*), common greenbrier (*Smilax rotundifolia*), and partridge-berry (*Mitchella repens*). Species common to the mixed oak/heath forest, such as white oak and American beech (*Fagus grandifolia*), may be present on upland margins of pond habitats. Surface substrate is mostly leaf litter when ponds are dry.

<u>Sweetgum – Swamp Black Gum / Cypress-Swamp Sedge Type</u>. This community occurs in the deepest portions of ponds experiencing long hydroperiods. The NVC synonym is *Liquidambar styraciflua – Acer rubrum – Nyssa biflora / Carex joorii* Association. This type is present at three of the four forested COLO seasonal pond management units (1, 4, and 5), but does not occur in Unit 2 (Tour Road Swamp). In addition to the nominal *Liquidambar styraciflua, Nyssa biflora,* and *Carex joorii*, characteristic species include overcup oak (*Quercus lyrata*), fetterbush (*Leucothoe racemosa*), royal fern (*Osmunda regalis*), and highbush blueberries (*Vaccinium corymbosum, V. formosum*). When ponds are not inundated, surface substrate is predominantly leaf litter, with some cover consisting of *Sphagnum* spp. Since black gum – rather than swamp

black gum – occurs at COLO sites, this natural community type name and concept has been broadened to include *Nyssa sylvatica*, which apparently substitutes for *Nyssa biflora* at COLO.

Rare plants. No rare, threatened, or endangered plant species have been documented to date from seasonal pond habitats at COLO. However, at least seven rare plant species have potential to occur at COLO in association with seasonal ponds (see Table 6).

Rare animals. In 1999, DCR-DNH zoologists discovered the state-listed (threatened) Mabee's salamander (*Ambystoma mabeei*) in Pond 10 at COLO. Surveys in 2000 and 2003 again found Mabee's salamander at this location. Although Pond 10 is the only current COLO location for this species, it is known from other seasonal ponds within the Grafton Ponds Complex. In 2003, a DCR-DNH zoologist discovered the state-rare (G5 S2?) southern chorus frog (*Pseudacris nigrita*) in Pond 12 at COLO. These are the only rare animal species that have been documented from COLO seasonal ponds (Table 4).

Table 4. Extant rare animals associated with seasonal ponds at Colonial National Historical Park.

Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status
Ambystoma mabeei	Mabee's salamander	G4	S1S2	none	threatened
Pseudacris nigrita	southern chorus frog	G5	S2?	none	none

Mabee's salamander is a pond-breeding amphibian which thrives in ephemeral ponds free of fish and other egg predators. Adults migrate to breeding ponds during warm, heavy rains in late winter or early spring (typically February – late March) and larvae hatch 9-14 days after eggs are oviposited. The larval period lasts a few months with larvae transforming (i.e., losing gills, growing legs) to the adult stage in early to mid-May (Petranka 1998). Adults return to ponds only for the purpose of breeding, spending most of the year in adjacent uplands, and largely in underground burrows.

Southern chorus frogs have only recently been documented in Virginia. The occurrence at COLO represents the northernmost known population for this species (C. Hobson, pers. comm.. 2004).

The importance of seasonal ponds to the faunal community is high, as many species depend on these wetlands for completion of their life cycle. Seasonal ponds are important water sources for wildlife both as a freshwater drinking source and as links connecting wetlands together for species, population, and individual movement (Kenny and Burne 2000). The continued existence and potential restoration of seasonal ponds is thus an important objective if the overall faunal diversity of COLO is to be maintained and enhanced.

Watchlist species. Two watchlist (S3) plant species – big carpet grass (*Axonopus furcatus*) (G5 S3) and slender spikerush (*Eleocharis tenuis* var. *verrucosa*) (G5T3T5 SNR) – were observed during the biological survey of COLO seasonal ponds conducted in 2000 (Van Alstine et al. 2001). Both species occurred in open field ponds (Ponds 6, 7, and 8) of Unit 3. Voucher specimens for these two species have been prepared and deposited in the Herbarium of the

College of William and Mary. One watchlist animal species is also present in association with COLO seasonal ponds – the Attenuated bluet damselfly (*Enallagma daeckii*) (G4 S3). This species has been observed at Pond 1 (Van Alstine et al. 2001) (Table 5).

Table 5. Watchlist species associated with seasonal ponds at Colonial National Historical Park.

Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status
Plants					
Axonopus furcatus	Big carpet grass	G5	S3	none	none
Eleocharis tennuis var *verrucosa*	Slender spikerush	G5T3T5	SNR	none	none
Animals					
Enallegma daeckii	Attenuated bluet (a damselfly)	G4	S3	none	none

Potential Natural Heritage Resources

Although few rare species were seen during recent field surveys (Van Alstine et al. 2001), a number of plants and animals rare to Virginia have potential either to currently exist or to become established in the future within seasonal pond habitats at COLO. Conditions at the Park are similar to those at other seasonal ponds on the Grafton Plain where rare species are known to occur. Seven species of rare plants have potential to occur at COLO, as well as at least one rare animal (Table 6). While only barking tree frogs (*Hyla gratiosa*) are known to currently occur on the Grafton Plain, it is possible that eastern tiger salamanders (*Ambystoma tigrinum*) and canebrake rattlesnakes (*Crotalus horridus atricaudatus*), both listed as state endangered, either currently or could in the future inhabit seasonal pond habitats at COLO (Clark 1998).

Table 6. Rare species with potential for occurrence within the Seasonal Pond Natural Area at Colonial National Historical Park.

Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status
Plants					
Calamovilfa brevipilis	Pine barrens reedgrass	G4	S1	none	none
Chelone cuthbertii	Cuthbert's turtlehead	G3	S2	none	none
Fimbristylis perpusilla	Harper's fimbry	G2	S1	none	endangered
Hypericum setosum	A St. John's wort	G4G5	S1S2	none	none
Litsea aestivalis	Pondspice	G3	S1	none	none
Sabatia campanulata	Slender marsh rose-pink	G5	S2	none	none
Sphagnum macrophyllum var. *macrophyllum*	Large-leaf peatmoss	G3T3	S2	none	none
Animals					
Ambystoma tigrinum	Eastern tiger salamander	G5	S1	none	endangered
Crotalus horridus atricaudatus	Canebrake rattlesnake	G4	S1	none	endangered
Hyla gratiosa	Barking treefrog	G5	S1	none	threatened

SEASONAL POND CONCEPTUAL ECOLOGICAL MODEL

A simple conceptual ecological model of the Grafton Ponds ecosystem has been developed by Clark (1998) for the purposes of enhancing understanding of the seasonal pond system and to provide a means to assess threats and develop management strategies. This model has good potential for use in management applications at COLO and has been included here. Conceptual models assist an understanding of which factors may be affected by management and can also help managers set priorities and measure success. Development of such models also serves as a learning experience and highlights what is both known and unknown about ecosystems. Thus, research and monitoring priorities are better identified. Conceptual ecological models can also be used as effective communication tools – explaining the ecosystem and management needs, leaving a record of current knowledge and assumptions, and posing questions for future resource managers. This model for the Grafton Ponds is based on extensive ecological research by DCR-Natural Heritage staff (Rawinski 1997) and focuses primarily on the plant community level; however, correlations to rare plant and animal species are emphasized.

Influencing Factors

Hydroperiod and canopy openness are the most significant factors influencing the ecology of seasonal ponds and are the primary variables in the model. Rawinski (1997) has demonstrated through ordination methods that variables related to hydroperiod are among the most influential factors affecting vegetation.

Hydroperiod. Hydroperiod – defined as the duration, frequency, and timing of flooding – strongly affects pond plant community composition and thus the habitat of animal populations. Hydroperiods vary from pond to pond and from year to year. Annual variation is mostly correlated to weather conditions: long hydroperiods occur during “wet years” while shorter hydroperiods occur during “dry years”. Much intra-pond variation is attributable to basin depth, canopy openness, and soil permeability. Deeper ponds tend to hold water longer; likewise, more open (treeless) ponds tend to hold water longer – presumably due to lower evapotranspiration (ET) rates (Allan 1995; Dunne and Leopold 1978; Mitsch and Gosselink 1993). Hydroperiod can be expressed as the maximum duration of flooding in weeks; that is, the number of weeks the deepest part of the pond holds water. Hydroperiods presented in the model are based on data collected in 1996 from ponds within the Grafton complex. Since 1996 was a relatively wet year, ponds may be flooded for fewer weeks than indicated by the model during dry years.

Canopy openness. The extent of canopy coverage by overstory trees is an indirect measure of the amount of sunlight reaching ground layer vegetation, the forest floor, or the water surface in seasonal pond systems. Canopy openness can be measured using a handheld spherical densiometer and is expressed in percent openness. A completely open canopy (no trees) has a value of 100%. For purposes of the model, openness is measured from the center point of each pond. In general, greater openness is associated with greater amounts and diversity of herbaceous ground cover vegetation. Canopy openness may also affect hydroperiod with more open ponds supporting lower ET rates and thus longer hydroperiods than ponds with more trees and higher canopy coverage. Inversely, ponds with longer hydroperiods often have fewer trees, likely due to

the specific adaptations required by tree species that spend much of the growing season with root systems inundated and experiencing anaerobic soil conditions.

Other factors. Several additional factors influence vegetation development in seasonal ponds; individually however, these are less influential than hydroperiod and canopy openness and are not considered in the basic conceptual model provided here. These factors include soil type, basin depth, basin area, water chemistry, and disturbance. Soils with low permeability tend to extend hydroperiod as surface water is slower to infiltrate the soil column. Basin depth and area (pond volume) are strongly correlated to hydroperiod. Water chemistry is a factor affecting plant and animal composition in seasonal pond communities; however, most ponds within the Grafton complex are similar in their acidity and low nutrient status (Rawinski 1997). Disturbances – whether or anthropogenic or natural – influence plant community composition in the ponds and adjacent uplands. For example, tree windfalls caused by Hurricane Isabel in 2004 had notable impacts on the Grafton ponds by increasing canopy openness. Human activities such as clearing forests for farming and development, mowing and herbicide use has influences plant communities by directly by removing vegetation and disturbing soils. Fires once would have widely influenced plant community composition and structure on the Grafton Plain prior to 20th century fire suppression efforts, and prescribed burning may prove to be a useful management tool for increasing and maintaining pond openness and restoring putative historical conditions. Finally, a host of further factors also influence the ecology of the Grafton Ponds complex, including nutrient dynamics, occasional extreme weather events, predation and herbivory, amount and characteristics of leaf litter, inter-pond water movement, and interspecific competition between organisms.

Vegetation Zones

Vegetation zonation is a conspicuous characteristic of seasonal ponds. Zones are expressions of the hydroperiod gradient and cross-sectional shape of individual ponds. Where pond slopes are gentle, vegetation zones are usually broad with vegetation types showing gradual change. On steeper pond slopes, zones are narrower and often change abruptly. The following zones are characterized by specific vegetation alliances and associations and are arranged in order of increasing hydroperiod and canopy openness. Not all zones exist in ponds located at Colonial National Historical Park; however, each can be found in ponds located within the Grafton Plain.

Vegetation zone A.

Acer rubrum – Nyssa sylvatica / Vaccinium corymbosum Alliance
(red maple – blackgum / highbush blueberry alliance)

Pinus taeda – Quercus phellos / Ilex opaca / Chasmanthium laxum type
(loblolly pine – willow oak / American holly / slender spikegrass community type)

The red maple – blackgum / highbush blueberry alliance is a common natural community throughout coastal areas of the mid-Atlantic and Northeastern U.S. The loblolly pine – willow oak / American holly / slender spikegrass community type represents this alliance on the Atlantic Coastal Plain of Virginia. In addition to plants listed in the community type name, sweet pepperbush (*Clethra alnifolia*), sourwood (*Oxydendrum arboreum*) water oak (*Quercus nigra*), swamp azalea (*Rhododendron viscosum*), and partridge-berry (*Mitchella repens*) are

characteristic. This is the highest elevation zone of vegetation associated with ponds on the Grafton Plain; thus, all ponds have this vegetation zone and some ponds have *only* this zone.

Vegetation zone B.

Liquidambar styraciflua – Nyssa biflora / Carex joorii type
(sweetgum – swamp blackgum / cypress-swamp sedge community type)

Diospyros virginiana / Saccharum baldwinii – Panicum verucossum sub-type
(persimmon / plumegrass – warty panicgrass sub-type)

Quercus lyrata / leaf litter sub-type
(overcup oak / leaf litter sub-type)

The sweetgum – swamp blackgum / cypress-swamp sedge community type usually occupies the second (lower) elevation zone in seasonal ponds on the Grafton Plain. The zone can either be expressed typically (sweetgum dominant), or as either of two sub-types: persimmon- or overcup oak-dominated. Most ponds on the Grafton Plain contain this vegetation zone. The rare plant, pondspice (*Litsea aestivalis*), occurs here at one pond within the Grafton Ponds Natural Area Preserve.

Vegetation zone C.

Dulichium arundinaceum – Scirpus cyperinus – Juncus repens type
(three-way sedge – woolgrass bulrush – creeping rush community type)

Cephalanthus occidentalis / Decodon verticillatus – Torreychloa pallida type
(common buttonbush / swamp loosestrife – pale mannagrass community type)

The common buttonbush / swamp loosestrife – pale mannagrass community type is typically the third zone down the elevation gradient within Grafton Plain seasonal ponds. It may be replaced or interdigitated by the three-way sedge – woolgrass bulrush – creeping rush community type which may occur on slightly higher elevations. Zone C is less common than zones A and B, and is not known to occur within seasonal ponds at COLO.

Vegetation zone D.

Lindernia dubia – Eragrostis hypnoides – Panicum dichotomiflorum type
(long-stalked false pimpernel – creeping lovegrass – fall witchgrass community type)

This community type constitutes the lowest (deepest water) vegetation zone and occurs in only some of the deepest seasonal ponds within the Grafton Ponds Complex. The plant community is comprised mainly of annual plant species whose seedbanks survive long periods of inundation and can grow and mature rapidly during brief periods of drawdown. Where the rare plant species, Harper's fimbristylis and featherfoil occur in seasonal ponds of the Grafton Plain, it is in this vegetation zone. During wet years when standing water covers the zone for extended periods of the growing season, this zone may not be evident. As with Zone C, this zone is not known to occur within seasonal ponds at COLO.

Vegetation zone E.

Cleared / mowed ponds

Although vegetation zonation does occur in seasonal ponds disturbed by mowing, no formal classification of these vegetation types has been attempted. Species frequently found on disturbed ponds of the Grafton Plain including those at COLO include dense panicgrass (*Panicum rigidulum var. condensum*), long-tubercled spikerush (*Eleocharis tuberculosa*), giant plumegrass (*Saccharum giganteum*), and soft rush (*Juncus effusus*). Rare plant species including Cuthbert's turtlehead (*Chelone cuthbertii*) and slender marsh pink (*Sabatia campanulata*) can occur in wet, disturbed areas such as in mowed seasonal ponds; however, these species are not known to occur within COLO mowed ponds. Fire is the primary natural disturbance factor that, prior to fire exclusion and mowing regimes, would have once maintained conditions suitable for a large number of both common and rare wetland herbaceous species on the Grafton Plain that require open to partially open, sunny conditions.

Pond and Community Types

Seasonal wetlands of the Grafton Plain have been classified (Clark 1998) based on the number and types of vegetation zones present. Additionally, general community designations for terrestrial and aquatic communities can be formed for use in the conceptual ecological model by lumping related plant community types. The six pond types and three general community types are described below. The likelihood of encountering two representative rare species – Mabee's salamander and Harper's fimbristylis – is noted in each description. Note that both pond and general community types are illustrative, not absolute. Many ponds or other natural communities at COLO may not fit entirely within a single category.

Type I. Type I ponds are characterized by a maximum hydroperiod of 6 to 12 weeks, but may not fill at all during some especially dry years. Canopies are closed, ranging from 5 to 40 percent maximum openness. Soils are usually silt loams with slow permeability, very slow runoff, and a seasonally high water table. Type I ponds typically contain only Vegetation Zone A with little to no development of concentric zonation. Some of these areas are seen as pine-dominated flatwoods. Neither breeding Mabee's salamanders nor Harper's fimbristylis occupy Type I ponds.

Type II. The maximum hydroperiod for Type II ponds is 12 to 18 weeks, but may not fill at all during some dry years. Type II ponds typically have slightly open canopies with maximum openness ranging from 20 to 50 percent. Soils are usually silt loams similar to those of Type I ponds. Type II ponds normally contain two concentric zones of vegetation: A and B. There is some potential for breeding Mabee's salamanders but no potential for Harper's fimbristylis.

Type III. These ponds usually have a maximum hydroperiod of 18 to 24 weeks and are flooded even during dry years. Type III ponds typically have a somewhat open canopy with openness values ranging from 40 to 70 percent. Because of longer inundation periods, soils are organic (mud and peat). Type III ponds normally contain vegetation zones A, B, and C with Zone C occurring in the areas of deepest water. There is good potential for breeding Mabee's salamanders and some potential for Harper's fimbristylis in Type III seasonal ponds.

Type IV. Typically, the hydroperiod ranges from 24 to 30 weeks for Type IV ponds. Canopies are often quite open, though they can range widely from 40 to 90 percent openness. As with Type III ponds, soils tend to be organic. Type IV ponds can support four vegetation zones: A, B, C, and D. There is good potential for both breeding Mabee's salamanders and Harper's fimbristylis in Type IV ponds; nearly all known populations of Harper's fimbrystylis on the Grafton Plain are within Type IV ponds. Another rare plant species – featherfoil – occurs in Type IV seasonal ponds.

Type V. Type V ponds are those deep enough to support three or four vegetation zones, but the area of the pond is so small that most herbaceous plants are shaded out and only one or two vegetation zones can develop (Zones A and B). Maximum hydroperiod is similar to Types III and IV – up to 30 weeks. Due to their small size, Type V ponds are shaded and closed with canopy openness ranging from 5 to 50 percent. Soils are usually silt loams. Some potential exists for breeding Mabee's salamanders; however, no potential exists for Harper's fimbristylis.

Type VI. These ponds are within disturbed areas – where trees have been cleared and low vegetation is maintained either by mowing and/or herbicide applications in order to retain open fields or rights-of-way. Type VI ponds occur on utility corridors, open fields, and in recently-harvested/planted forest areas. Hydroperiods tend to be long relative to pond depth due to decreased ET rates – from lack of tree cover – ranging from 18 to 30 weeks. Openness is near 100% and vegetation is consistent with that described in Zone E. Plant species richness is often highest in Type VI ponds – as is the case for field ponds at COLO (Van Alstine et al. 2001). While zonation can occur, plant composition in zones has not been determined for disturbed seasonal ponds within the Grafton Complex (Clark 1998). If hydroperiods are sufficiently long, there is good potential for rare species to occur in some disturbed ponds. Natural disturbances such as fire, windstorms, ice storms, and interacting combinations of these events would have once helped to maintain the required habitat conditions for many pond-associated species. For Mabee's salamanders, breeding habitat quality depends on the distance from ponds to the closest forested areas required by adults during the non-breeding season. Harper's fimbristylis requires relatively deep and open ponds; however, the many invasive non-native plant species common to disturbed field ponds may disrupt the seedbank or out-compete this plant rarity.

Type U. This symbol represents plant community types on forested uplands surrounding seasonal ponds. Several common upland forest communities constitute this type, but specific community types have not been characterized. Canopy dominant species are mostly loblolly pine and various oak species. Average canopy openness prior to Hurricane Isabel in 2003 ranged from 5 to 40 percent; however, following extensive windthrow of large forest trees, canopies are currently (2005) much more open in many places. While there is no potential for Harper's fimbristylis or breeding Mabee's salamanders in the uplands, both sub-adult and adult Mabee's salamanders home ranges may include substantial areas of upland forest during the non-breeding season.

Type F. Numerous streams with associated narrow floodplain forest bisect the Grafton Plain. Hydroperiods of these floodplains average less than 6 weeks per year and are characterized by infrequent, short-duration flooding from storm events. Canopy openness ranges from 5 to 40 percent, with greater openness associated with hurricane-caused light gaps following Isabel in

September 2003. Dominant canopy species include yellow-poplar, sycamore, and red maple. The understory is often dense and consists of pawpaw (*Asimina triloba*), spicebush (*Lindera benzoin*), American hornbeam (*Carpinus caroliniana*), and flowering dogwood (*Cornus florida*). These habitats do not support either Harper's fimbristylis or Mabee's salamander.

Type S. Streams and springs constitute a separate natural community type. Most, but not all, of the stream courses on the Grafton Plain are perennial with a hydroperiod approaching 52 weeks; both springs and runoff constitute water sources for stream flow. Streambed substrate is fine sand with some organic detritus and variable amounts of coarse woody debris. Deposits of ancient shells are exposed is some places along streambanks. Natural community types for these aquatic communities have not been specifically characterized, and none of the types present at Grafton support either Harper's fimbristylis or Mabee's salamander.

Conceptual Ecological Model

A simple conceptual model (Figure 4) has been developed for seasonal pond plant communities on the Grafton Plain which integrates key influencing factors to predict certain pond functions – in this case, suitability as habitat for two important rare species occurring within the Grafton Pond Complex: Mabee's salamander and Harper's fimbristylis. Currently, Mabee's salamander exists only at one known location within COLO and Harper's fimbristylis is unknown from COLO. This model can be used as a tool to assess habitat suitability and potential for restoration of these two species in the Park, and will guide management decision making when considering the habitat needs of these species. Further, the model can be used as a template for developing future decision-making tools for use with other species associated with seasonal ponds.

Hydroperiod and canopy openness are the primary influencing factors in the model, assigned to the X and Y axes, respectively. Community (and pond) types are ordinated according to their ecological limits with regard to the two variables (Figure 4). To further illustrate the characteristics of each community type, symbols indicating the number of vegetation zones, high potential for breeding Mabee's salamanders, and high potential for Harper's fimbristylis appear on the diagram where appropriate.

From the model, generalized predictions can be inferred when one or both of the primary variables change. For example, a decrease in canopy openness and hydroperiod might cause a Type III pond to succeed to a Type II pond – reducing its potential as Mabee's salamander breeding habitat. A decrease in openness alone could cause a Type III pond to become a Type V pond where suitability for Mabee's salamanders is decreased solely due to increased shading and decreased herbaceous vegetation cover. Various implications of change on overall plant diversity or presence of target rare species can be elucidated with the model. In the above examples, change of a Type III pond to either a Type II or Type V could possibly result in the loss of Vegetation Zone C and the loss of a breeding site for Mabee's salamanders.

To supplement this ecological model, a "hydrological clock" (Figure 5) has been developed. The diagram shows the relative water level in a representative seasonal pond over the course of a year and illustrates the relationship between pond hydrologic cycle and life history of two rare species – again, Mabee's salamanders and Harper's fimbristylis.

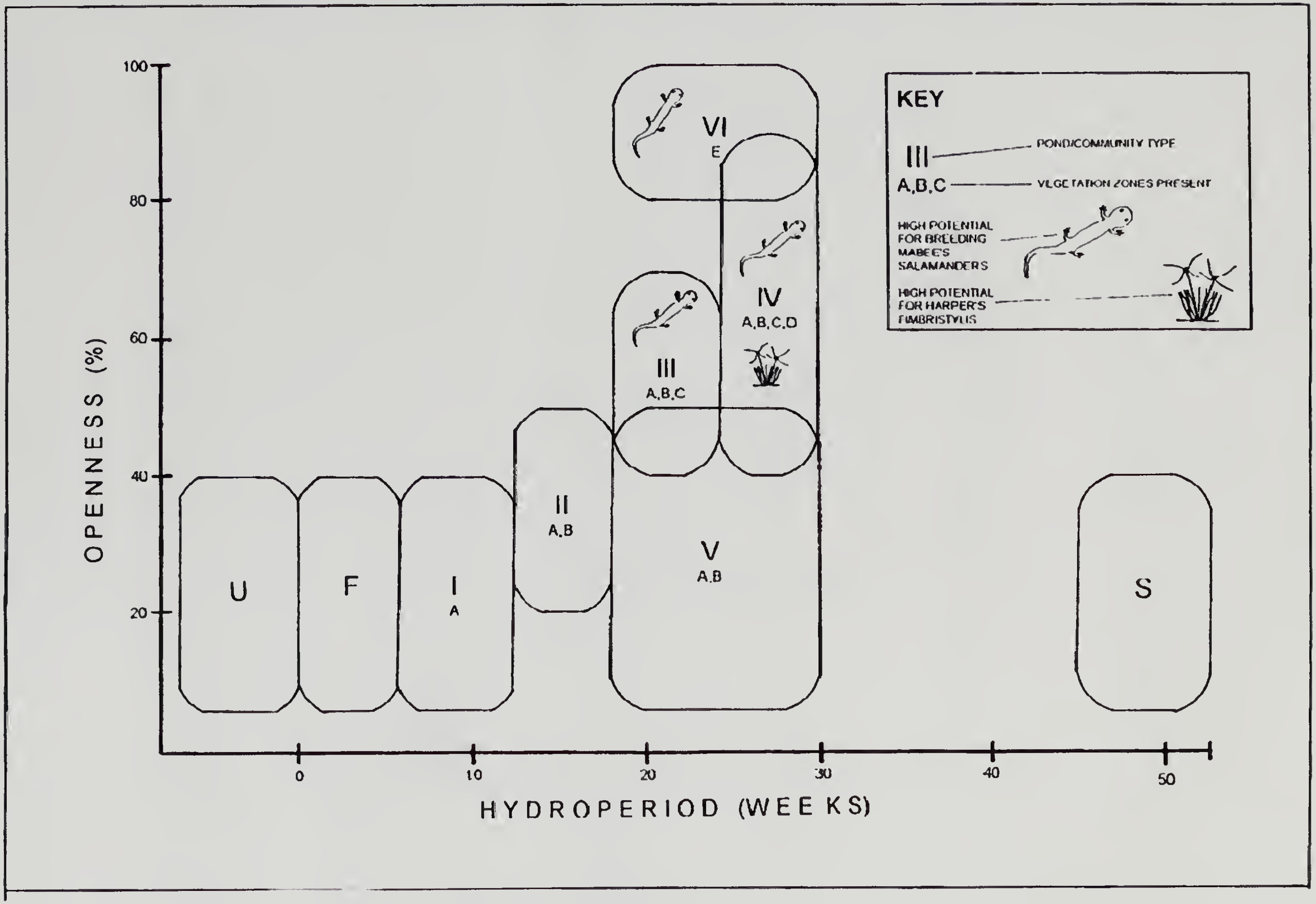

Figure 4. Grafton Plain seasonal pond conceptual ecological model.

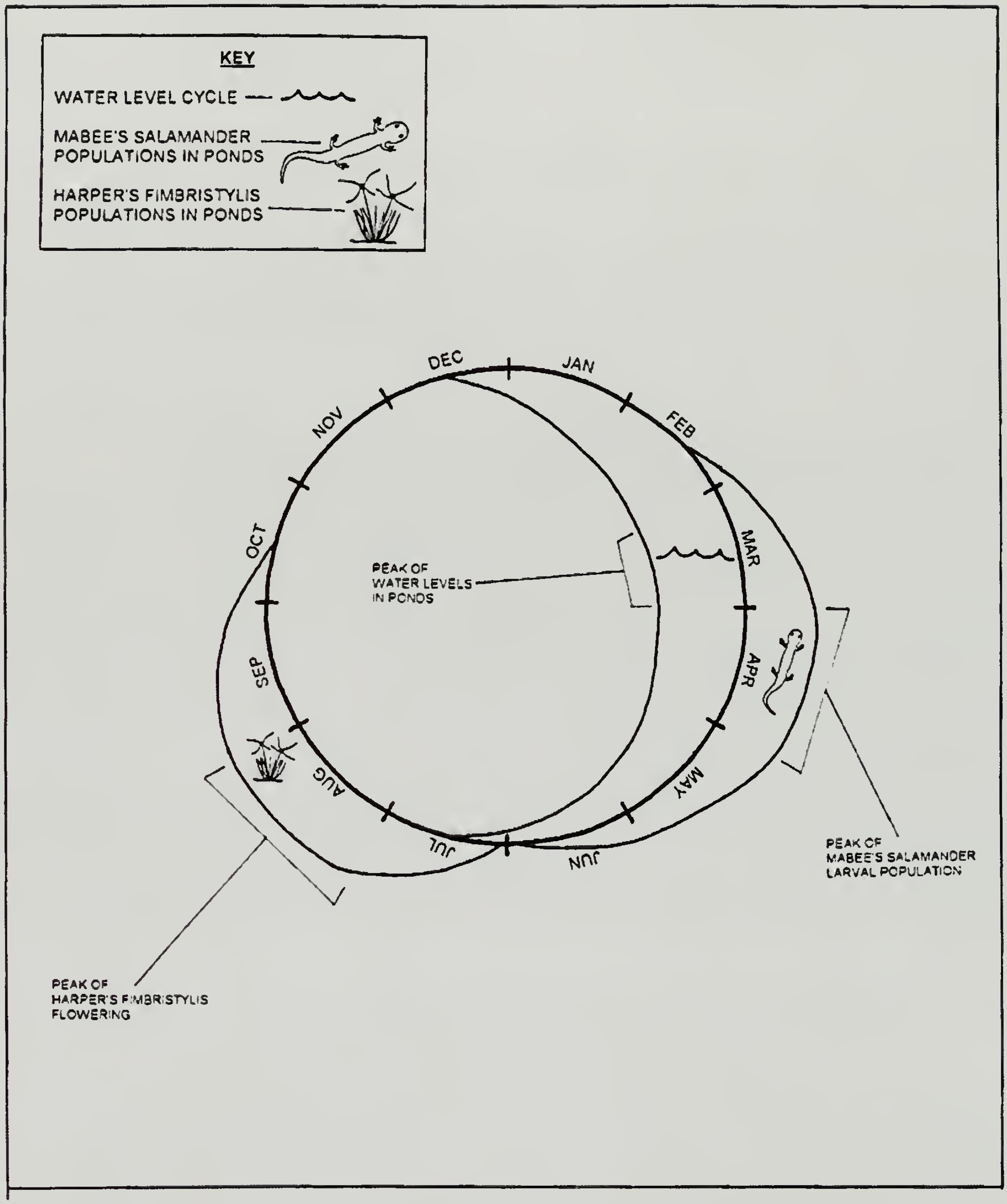

Figure 5. Hydrological "clock" depicting a typical annual cycle of Grafton Ponds hydrology with selected rare species' life cycles.

GENERAL MANAGEMENT ISSUES AND RECOMMENDED ACTIONS

Issues have been identified and monitoring / management actions are recommended in order to benefit natural heritage resources associated with seasonal ponds and their surrounding upland habitats. Seasonal pond management issues include influences that directly impact resources (e.g. trampling, poaching), and also which (more commonly) have indirect effects that interfere with natural processes sustaining rare species and natural communities. **The biota of seasonal ponds at COLO is currently (or will likely in the future be) affected in adverse ways by the following:**

1. Invasive non-native plants
2. Native problem species (that have become overabundant)
3. Exclusion/suppression of natural (lightning-ignited) wildland fires
4. Incompatible public uses
5. Alteration of hydrological regimes
6. Sedimentation and other water quality degradations

The following general management issues pertain, in most cases, to all management units within the Seasonal Pond Natural Area. In some cases, the issue may pertain to a subset of the units. Specific descriptions of individual management units and those unique issues affecting them are presented in the next chapter.

Status of Natural Heritage Resources

Known occurrences of natural heritage resources require periodic monitoring and data updating. Changes in habitat condition, such as from invasions of non-native plants or following canopy disturbing events such as hurricanes, can lead to changes in abundance and/or presence of rare plants and animals, as well as natural communities.

Potential occurrences of natural heritage resources (those which may now or could in the future occur) should be investigated by conducting periodic intensive surveys. Such field investigations are warranted due to the possibility that rare species may exist – so far undetected – in the vicinity of seasonal ponds and due to the potential for mobile species to use these habitats in the future. In particular, if management regimes recommended in this plan are implemented (prescribed burning, habitat restoration), the potential for new or expanded occurrences of rare species occurring in metapopulation on the Grafton Plain will be increased.

Recommendations. Annually to biennially, monitor condition and presence of natural heritage resources. Monitor and assess / describe changes in seasonal pond community structure and composition, especially if disturbance from wind, ice, or fire occurs. Conduct intensive surveys to search for potential occurrences, especially following disturbance/management events.

Invasive Non-native Species

Control of invasive non-native species is expensive. Since resources are limited, management efforts must be prioritized (Hiebert and Stubbendieck 1993). The goal of management is to

prevent the worst invasive species from becoming established in high-quality natural communities. Eradication may not be a practical option for many invasive species already well-established at COLO (Gounaris and Grubbs 2000). However, preventing new invasive species from getting established on the preserve is a viable objective. Control efforts should be prioritized, focusing on reducing the abundance of the most problematic invasive species in the highest quality natural communities (Akerson et al. 2000).

The six forested seasonal ponds (1, 2, 9, 10, 11, 12) are currently (2004) mostly free of invasive plant species. Exceptions are small patches of highly invasive Japanese stilt-grass and Japanese honeysuckle (*Lonicera japonica*) around Pond 2. The extensive uprooting of trees at COLO by Hurricane Isabel in September 2003 exposed thousands of small areas of mineral soil in tip-up mounds, which will likely accelerate the spread of invasive plants, in particular, Japanese stilt-grass. The six field ponds (3, 4, 5, 6, 7, 8) support numerous invasive plant species including velvet-grass (*Holcus lanatus*), meadow fescue (*Lolium pratense*), Bermuda grass (*Cynodon dactylon*), and sheep sorrel (*Rumex acetosella*). Non-native sweet vernal grass (*Anthoxanthum odoratum*) is present but is not currently considered invasive in Virginia (DCR-DNH 2004).

Japanese stilt-grass (*Microstegium vimineum*). Stilt-grass is extremely widespread throughout COLO. It occurs in large dense patches in forest openings, on streamsides, and along trails and roads (Gounaris and Grubbs 2000). This species is a native of Asia and is now widespread east of the Mississippi (Hunt and Zaremba 1992; Redman 1995; Ehrenfeld 1999). Japanese stilt grass is typically an annual grass, although a perennial form has apparently been discovered (Ehrenfeld 1999), that spreads into mesic forest habitats. It spreads rapidly into disturbed areas but can invade undisturbed upland areas by forming satellite populations brought in by animals or flooding. It is generally slow to invade undisturbed areas, but rapidly fills disturbed areas such as flood-scoured stream sides, tip-up mounds, and along roads and trails. Japanese stilt-grass is generally avoided by deer as a food resource (Tu 2000).

An individual plant of Japanese stilt-grass can produce up to 1000 seeds, which can remain viable in the soil for three to five years. Once established, Japanese stilt-grass is able to crowd out native herbaceous vegetation in wetlands and forests within three to five years (Barden 1987; Hunt and Zaremba 1992). Manual / mechanical, environmental / cultural, and herbicide methods have all been used with some success for control of Japanese stilt-grass. Prescribed burns have not been successful in controlling this species so far, but fall burns may have the potential for partial control.

Recommended actions. Periodically monitor and assess effects of invasive plant species on seasonal pond natural communities and affected native species. Establish quantitative monitoring protocols for those invasive plants determined to be current or potential problems. Keep an especially close watch on invasions of Japanese stilt-grass, which is likely to colonize at an increased rate at COLO due to the creation of innumerous mineral soil establishment sites on tip-up mounds and adjacent depressions during Hurricane Isabel in September 2003. If controlled during the early stages of invasion, the potential for successful management of stilt-grass is high. The potential for large-scale restoration of wildlands where Japanese stilt-grass has become established is, at best, moderate (Tu 2000). Grass-specific herbicides may need to be used to control Japanese stilt-grass at the cost of sacrificing some native grass species populations. The

best combination of control for Japanese stilt-grass will likely involve mowing / cutting in late summer prior to seed set and spot treatments of herbicide in early summer, along with the use of pre-emergent herbicides in late winter.

Exotic mosquitoes and West Nile Virus. While many non-native animal species in and around seasonal ponds (e.g. European Starlings, cabbage white butterflies, house mice) pose no known threats to native fauna, natural community integrity, or ecosystem functions, a notable exception is the recently-introduced West Nile Virus, which may have serious impacts on many species of native fauna (Weiss 2002) in addition to its better-documented adverse health consequences in humans. The extensive uprooting and toppling of large trees during Hurricane Isabel may also have consequences for mosquito control on the Grafton Plain since seasonal ponds are less easily accessed for land-based larval control operations due to the many downed trees. In addition, the thousands of tip-up depressions caused by hurricane uprooting of trees has most certainly increased the area of standing water, which likely translates to increased breeding habitat for mosquitoes.

Recommended actions. Develop contacts and provide seasonal pond resource information to York County mosquito control staff in order to coordinate needed mosquito/disease vector control actions when conditions warrant. Develop control guidelines that reduce non-target effects of control treatments on rare and other native biota of seasonal pond communities while still protecting human health.

Native Problem Species

Due to overabundance, certain native species of animals have become problematic – from both ecological and economic perspectives. While these species are native to Virginia, their recent population increases have resulted in negative effects on habitat and to other aspects of human coexistence. Overabundance of some animal species is often incompatible with a broad array of resource management objectives.

White-tailed deer (*Odocoileus virginianus*). A large body of research (Russell et al. 2001) presents evidence that dense populations of deer in many eastern U.S. ecosystems are negatively impacting tree regeneration, recruitment and composition (Alverson and Waller 1997; Horsley et al. 2003), altering natural community composition (Rooney and Dress 1997), eliminating certain plant species from areas (Augustine and Frelich 1998), and disrupting bird populations (deCalesta 1994; McShea and Rappole 1997). Deer are known to avoid browsing some invasive non-native plants such as Japanese stilt-grass (Tu 2000) and garlic mustard (Nuzzo 1991), which can exacerbate the negative effects of these weeds on native flora. Of particular concern for natural areas managers are the negative effects of high deer densities on herbaceous plants (Anderson 1994; Balgooyen and Waller 1995; Augustine and Frelich 1998) and rare plants (Miller et al. 1992).

It is estimated that the presettlement deer density of the eastern U.S. was about 8 to 11 deer/mi^2 (McCabe and McCabe 1997). At the end of the 19th century, deer were over-hunted to the point of near extirpation from Virginia. Since then, the implementation of strict game laws, the elimination of natural predators, and the changing landscape of the state with more edge habitats

has given rise to a burgeoning deer population that today, in most areas of the state, exceeds the estimated presettlement deer densities (Knox 1997).

A number of studies have demonstrated that deer densities >20 deer/mi^2 can have negative impacts on tree regeneration, recruitment and composition (Tilghman 1989; Healy 1997; Horsley et al. 2003). Forests with deer densities of 8-15 deer/mi^2 have well-stocked and more diverse woody understories (Healy 1997) and abundant and flowering populations of such deer sensitive species as *Trillium grandiflorum* (Anderson 1994) and *Laportea canadensis* (Augustine et al. 1998). It should be noted that effects of deer on forest ecosystems depends on the landscape context in which they occur (Horsley et al. 2003). Forest stands in landscapes with a significant amount of agricultural row-crop land may be less impacted by the same density of deer than a forest stand in a primarily forested landscape.

York County has an estimated average deer density that exceeds 30 deer/mi^2 (VDGIF 1999). In 2003, the York County deer harvest was 13.28 animals per square mile of deer habitat – this was the seventh highest county harvest rate (per square mile of habitat) in the state (Phil West 2004, personal communication). At COLO, a relatively high deer density is indicated by obvious browse lines in most forested areas. A recent (2002) outbreak of Type II Hemorraghic Disease (HD) caused considerable mortality of deer at the park.

Recommended actions. It is recommended that a monitoring/research program be considered to ascertain deer population densities and deer impacts on seasonal pond resources in order to assess the specific need for and success of future deer management programs aimed at benefiting seasonal pond resources at COLO. Research should be conducted to determine if and how deer browsing may be affecting the groundcover vegetation within seasonal pond communities. In particular, it should be determined whether and how deer impact the spread of invasive species such as Japanese stilt-grass.

Deer population pressures can be assessed in terms of deer densities and/or deer impacts (Horsley et al. 2003). Deer density can be monitored via a number of techniques including deer harvest data (DGIF 1999), counts at dusk (Storm et al. 1992), the drive method (DeCalesta 1994), pellet counts (Neff 1968; White 1992; Alverson and Waller 1997), winter aerial surveys (Augustine and Frelich 1998) and line-transect sampling (Burnham et al. 1980; Healy and Welsh 1992). Population data on sensitive or "indicator" herbaceous plants have been used as a relatively crude but quick method of gauging the impact of deer populations on natural communities (Anderson 1994; Balgooyen and Waller 1995; Augustine and Frelich 1998; Augustine et al. 1998). Monitoring trends of deer impacts with exclosure plots and measurements of sensitive herbaceous ground flora plants is also recommended. Exclosure plots need not be large and part of a replicated experimental design. Tracking trends in vegetation types that reflect deer densities is a valid monitoring approach. It is recommended that small, 100 ft^2 exclosures be used that are easily constructed and monitored. Various studies have effectively used plots of this size (Alverson and Waller 1997; Healy 1997), sometimes paired with control plots located nearby and/or within similar vegetation.

Any management of the deer population must be based on clear and quantifiable management objectives tied back to original legislation, laws, NPS policies and specific COLO management documents.

Beaver (*Castor canadensis*). Although beavers are a native species and a component of Virginia's natural landscape, in certain situations large local populations of these animals can degrade and/or destroy natural heritage resources, including habitats for rare species as well as rare natural community occurrences. Like white-tailed deer, beavers were over-harvested in the 19^{th} century but have since rebounded in population size. They have continued to increase in population size due to marked decline in trapping pressure and a near absence of natural predators in Virginia (Linzey 1998). Beavers can destroy rare plant habitat and natural communities by creating dams on streams that inundate and/or silt in sites supporting natural heritage resources (Hammerson 1994; Wilson 2001). In the Northeast, beavers have been implicated in the destruction of sites for the federally endangered northeastern bulrush (*Scirpus ancistrochaetus*) (USFWS 1993). In Virginia, beavers have negatively impacted populations of the federally protected rare swamp-pink (*Helonias bullata*) and the state-rare Kentucky lady's slipper orchid (*Cypripedium kentuckiense*) (Myers 2004, pers. comm.).

Certainly, beavers have routinely modified streams and altered wetlands of the U.S. presettlement landscape. However, in that landscape context, timber wolves (*Canis lupis*) as well as native humans would have frequently preyed on beavers, helping to keep their numbers in balance (Wilson 2001). Further, seasonal ponds have today become a threatened habitat type. Special sites supporting high-quality, rare wetland communities such as seasonal ponds at COLO may require consideration and protection from what is, arguably, an artificially-high beaver population. Numerous (most) stream and wetland sites around COLO do not harbor natural heritage resources and, thus, provide habitats where beavers can (and should) be free to create impoundments and sustain their numbers.

Recommended actions. Within the Seasonal Pond Natural Area, beaver activity should be monitored with special attention given to Unit 2 where surface drainage connection between Pond 2 and Beaverdam Creek is evident. First dams, then populations (if needed) should be considered for removal if they become established. Water level control devices can also be used to mitigate the effects of established beaver dams by preventing further flooding (Wilson 2001) or lowering water levels. This alternative should be considered as a solution for well-established beaver populations. However, these devices and relocation of beavers are not effective at preventing the creation of new beaver dams. As necessary, trapping could be considered since this is the most practical method of controlling beaver populations (Wilson 2001). Should the need arise, COLO resource managers should work with DGIF wildlife biologists in developing a strategy to effectively manage beavers.

Southern pine beetle (*Dendroctonus frontalis*). Southern pine beetle is a native insect species that attacks stressed or dying pine trees (including both loblolly and shortleaf pines), as well as pines infested previously by other native bark beetles (Coulson and Witter 1984). This species causes significant damage in cycles; and, when outbreaks occur, the beetles can attack, colonize, and kill even vigorous healthy trees. Pine stands that are either overly dense, drought stressed, or physically damaged in some way (e.g. lightning strikes) are most susceptible to

southern pine beetle attack. Dense stands of pine susceptible to southern pine beetles are other thinned in order to promote more vigorous residual trees, which can reduce the risk of mortality (Swain and Remion 1981). The natural thinning that occurred during Hurricane Isabel may have benefited surviving pines at COLO; however, storm-damaged (stressed) pines could also act as an attractant for future pine beetle infestations.

Recommended actions. Since many upland forests surrounding seasonal ponds at COLO contain pine species as important canopy dominant, periodic monitoring for pine beetles is needed. If an outbreak occurs, COLO should consider standard control methods (cutting and burning and/or removing infested trees). Any and all control will follow NPS Integrated Pest Management Policies and procedures. Prescribed fire is another tool that can be used to lessen the outbreak potential of southern pine beetles. For more on this subject, refer to the discussion of prescribed fire at COLO in the Fire Management Plan for the Park (currently under development).

Fire Exclusion

Naturally occurring periodic fires are a key process that has maintained many plant communities of Virginia. Recurring low-intensity fires ignited both by lightning and native peoples were a prevalent fact on the coastal plain of pre-settlement Virginia (Brown 2000). As was the case in many vegetation types throughout the southeastern U.S., fire would have kept seasonal ponds and adjacent uplands on the Grafton Plain in a relatively open condition, maintaining diverse herbaceous groundcover vegetation and preventing development of the dense forest understory layer so typical of coastal plain habitats in Virginia today. Open seasonal ponds in a forested setting would have helped to sustain populations of herbaceous plants now rare in Virginia (see Table 6), and also would have provided improved habitat conditions for rare wetland animals such as Mabee's salamander and southern chorus frogs by increasing the abundance of common emergent herbs such as sedges and rushes (Hobson 2004, pers. comm.).

Depending upon frequency, intensity, and severity, wildfires and prescribed fires may or may not benefit natural communities or yield desired long-term ecological or programmatic goals of NPS regarding management of the Seasonal Pond Natural Area at COLO. A Fire Management Plan (FMP) is currently being prepared by the Park Service for COLO, with Doug Raeburn (former Shenandoah National Park FMO) as lead author. Fire management issues identified in this Management Plan for the Seasonal Pond Natural Area at COLO should be forwarded to the author of the COLO FMP under development.

Recommended actions. If suppression is required in response to a wildfire, the first response should use low impact techniques appropriate to the situation. For example, indirect attack using existing firebreaks is, from a natural areas management perspective, preferable to direct attack using fire plows since soil disturbance is likely to result in new invasions of exotic species – in particular, Japanese stilt-grass. Unless a critical situation requires construction of new control lines involving major soil disturbance, it is recommended that fire plows and bladed lines not be used due to the likelihood that new invasions of exotic species. Also, plow lines should be avoided in proximity to seasonal ponds so as to avoid alteration of surface hydrology.

It is also recommended that the ecological basis, resource benefits, and practicality of using prescribed fire as a management tool for maintaining and restoring seasonal pond natural communities, including a comparison with alternate techniques, be an integral part of the FMP currently under development for COLO. The FMP should address prescribed fire as well as wildfire issues and take into account the role of fire in maintaining functional seasonal pond communities and restoring rare species habitats.

If it is determined to be appropriate and feasible, and as directed by the COLO Fire Management Plan, a prescribed fire program to restore and maintain functional seasonal pond communities should be implemented.

Incompatible Public Use

Certain human activities are compatible with the habitat conservation focus for seasonal ponds, while some activities are not. Incompatible activities are those that directly or indirectly threaten natural area resources and values. Compatibility of many activities is influenced by spatial, temporal, and intensity factors. An activity that is compatible on portions of COLO, during a given season and at a given intensity may not be compatible in a different area, season, or intensity level. Activities generally considered to be compatible within the Seasonal Pond Natural Area include photography, birdwatching, and wildlife observation. Activities which are incompatible include significant soil and substrate disturbance (such as for road construction), surface and groundwater flow alterations, unauthorized collection of plants or animals, off-road motorized vehicle use, horseback riding, and operation of off-road ("mountain") bicycles.

Recommended actions. Monitor and control public use to allow levels and types of use which are compatible with preservation of seasonal pond resources while excluding others. Coordinate road improvement and maintenance activities within the Park to prevent road designs that threaten or diminish habitat and corridors for herpetafauna migrations. For example, consider culverts/underpasses on new road sections or consider retrofitting existing sections where concentrated herpetafauna crossings are known. Monitor and ensure the use of BMPs during all construction or road maintenance activities within or adjacent to the Park when seasonal pond resources may be impacted.

Watershed Protection

Seasonal pond water quality and quantity, as well as the biotic resources that depend on the water resource of ponds, are directly affected by activities of humans within the pond watershed and groundwater recharge area. Little information exists regarding the impacts of various land use practices on water quality / quantity in coastal plain seasonal ponds, so it is usually difficult if not impossible to demonstrate cause and effect. Resource managers should monitor surrounding land uses – such as road construction projects and increased well-water withdrawals and new well construction – and pond water resources to document possible correlation of observed changes in seasonal pond characteristics. Smaller scale disturbance – such as the unauthorized construction or use of mountain bike trails in Park woodlands near seasonal ponds – can be detected by periodic monitoring visits to and within the Seasonal Pond Natural Area management units. This particular unauthorized use has been problematic on the nearby Grafton Ponds Natural Area Preserve; thus, it and other potential incompatible public use types have potential to occur at COLO.

Much, if not most, of the reasons for misuse or abuse of seasonal pond resources results from a pervasive lack of awareness (on the part of both the visiting and neighboring public) about the unique values that seasonal pond wetland habitats provide. With sufficient dissemination of information about the importance and benefits of seasonal ponds, many watershed protection issues are likely to be alleviated.

Recommended actions. Enforce existing local, state, and federal wetland and watershed protection laws as well as NPS policies and regulations for use of park lands. Conduct appropriate periodic monitoring visits and use law enforcement measures, as needed, to ensure the visiting public and neighboring landowners are not negatively influencing seasonal pond resources. Develop and distribute information to the visiting public at COLO about the significance of the Grafton Ponds Seasonal Pond Complex. Produce and install appropriate signage (including interpretive) for COLO seasonal ponds. Design and construct an interpretive trail in at least one seasonal pond management unit in COLO.

Neighbor Relations

Field observations, both during the Natural Heritage inventory (1999-2000) and during the development of this management plan – have indicated the presence of dumped materials in at least one pond (#11) at COLO. Appearances would lead to the conclusion that adjacent landowners have been responsible for the dumping. While no hazardous materials or other pollutants were observed or suspected, the practice of depositing even benign organic waste (old Christmas trees, coarse woody debris) is disturbing and could indicate a trend or potential on the part of COLO's neighboring landowners to consider seasonal ponds as acceptable places to dispose of various forms of refuse. Additionally, upslope (east) of Ponds 11 and 12, the City of Newport News has apparently placed quantities of old building materials – apparently from demolition projects. Some possibility exists for these materials to leach substances into surface and/or ground water and affect water chemistry in the Unit 5 seasonal ponds.

In addition, various resource management issues transcend property boundaries. For example, mosquito control methods to address human health concerns on the Grafton Plain as well as efforts to manage the Grafton Plains deer population will likely only be successful if multiple landowners work in concert to achieve shared objectives.

Recommended actions. Develop contacts and conservation agreements with neighboring private landowners in order to disseminate information about the importance of seasonal ponds. Maintain open lines of communication between NPS and landowners along Crawford Road, Siege Lane, and in the Edgehill neighborhood regarding management issues pertaining to seasonal ponds. Conduct periodic and seasonal monitoring and ranger patrols.

Coordinate with adjacent and/or nearby public landowners (City of Newport News) and stewards (Department of Conservation and Recreation) of seasonal pond resources on lands of the Grafton Ponds Natural Area Preserve in order to meet broad conservation goals on the Grafton Plain and to coordinate management strategies for landscape issues (e.g. mosquito control, deer population management, insect/disease outbreaks, groundwater withdrawals, etc.).

Convene periodic Seasonal Pond Complex management coordination meetings between NPS, Newport News, York County, and DCR staff to discuss management issues related to seasonal pond resources. Devise mosquito control strategies that minimize harm to native and potentially rare seasonal pond fauna while at the same time limiting the potential for human disease and protecting public health.

General Data Gaps and Research Needs

Specific studies of the effects of the COLO / York County deer population on seasonal pond natural communities – with a particular focus on the ways in which deer may be affecting invasive plant demographics – are needed to make informed decisions about the need for deer population management.

Recharge zones for shallow aquifer charging are currently unknown. Hydrological studies could improve understanding of surface water and groundwater recharge relationships, define the groundwater recharge area, and clarify the respective roles of groundwater and surface water in providing source water for COLO seasonal ponds. Critical recharge areas could be determined and future efforts directed at protecting these areas. To accomplish this, boundaries of surface watershed for each pond could be determined and mapped by analysis of detailed topographic data with field verification. This determination of surface watersheds for each pond could also be used to approximate source areas for groundwater inflow to the ponds. This information would be useful to Park managers for protecting water quality – particularly of surface inflow to seasonal ponds.

Literature searching and fire effects studies are needed to investigate the potential success of using prescribed fire in managing (restoring and maintaining) seasonal pond communities on the Grafton Plain. The historical role of fire in the maintenance of mid-Atlantic seasonal pond species assemblages and vegetative cover types is poorly understood. However, the role of fire in maintaining similar systems of isolated wetlands within frequently burned southeastern savannas and flatwoods is relatively well known.

General Management Issues Summary

As noted above, the five management units comprising the Seasonal Pond Natural Area at COLO have certain key management issues in common. These are summarized in Table 7. Additional unit-specific management issues, unit descriptions, recommendations, and data gaps are provided in the following chapter.

Table 7. Summary of key issues applicable to all Seasonal Pond Natural Area management units.

Management Issue	Recommendations
Status of natural heritage resources *Priority*: HIGH	Annually to biennially, monitor for condition and presence of natural heritage resources and assess trends or describe changes in community structure and composition, especially if major disturbance from wind, ice, wildfire, insects, or other factor occurs.
Invasive non-native plants *Priority*: HIGH	More than other species, Japanese stilt-grass has (or is likely to) become a problem in many portions of the Seasonal Pond Natural Area. Monitor all units closely and conduct control measures if invasions are detected. Monitor for other species, as indicated in the COLO Invasive Species Management Plan. As needed, conduct control actions using NPS Integrated Pest Management practices.
Native problem species *Priority*: MODERATE	Monitor vegetation plus deer, beaver, and southern pine beetle populations. Assess and determine current effects of deer browse on community composition, succession patterns, and rare plant species presence / absence. As needed, conduct management actions using NPS Integrated Pest Management practices.
Fire exclusion *Priority*: MODERATE	Complete COLO FMP with consideration of role of fire in maintaining diverse seasonal pond communities. As indicated and feasible, conduct prescribed burns to restore function and diversity of seasonal ponds communities and surrounding upland habitats.
Incompatible public use *Priority*: MODERATE	Monitor for public uses that are known to have potential to harm water quality or directly threaten rare animal species. In particular, monitor unauthorized activities such as off-trail mountain biking, horseback riding, and collection of plants and animals. Enforce use regulations and educate visitors about seasonal pond significance.
Watershed protection *Priority*: MODERATE	Monitor for earth-disturbing activities upslope of ponds on both NPS and non-NPS lands. Monitor for spills or dumping of potentially harmful materials/substances within pond watersheds. Coordinate all NPS construction activities (trail-building, road improvements) to avoid impacts to seasonal ponds.
Neighbor relations *Priority*: MODERATE	Monitor for dumping or other unauthorized and potentially harmful activities. Develop and distribute information to neighboring landowners about the significance of seasonal ponds. Coordinate with Newport News, DCR, and York County on projects including mosquito control, public education, invasive species control efforts, and native problem species management strategies.

MANAGEMENT UNIT DESCRIPTIONS AND SPECIFIC RECOMMENDATIONS

Five management units comprise the Seasonal Pond Natural Area at COLO. Individual descriptions for each management unit are provided and contain the following information:

- Unit name, reflecting the geographic locality or an associated landscape feature.
- Unit information, consisting of a brief description of the unit location within COLO, unit size (area), vegetation, key features, natural heritage resources, and biodiversity rank (B-rank).
- Natural heritage resource summary table, providing a synopsis of rare species and natural communities documented to date from the unit.
- Unit-specific listing of management issues affecting rare species and communities, water quality, and other resources.
- Monitoring recommendations pertaining to specific management issues identified.
- Management recommendations describing actions considered necessary for perpetuating or restoring natural heritage resources.
- Data gaps and research needs where information is lacking regarding a specific management issue. For example, if there is insufficient information regarding surface hydrology to support a recommendation for wetlands restoration, a recommendation is made to conduct detailed topographic surveys to provide a basis for decision making.
- Unit maps (Figures 6 - 10), depicting management unit boundaries, pond locations, and other information relevant for resource management planning.

Unit 1 – Crawford Road Pond

Unit information. Unit 1 covers 38.4 ac (15.5 ha) – including some areas of private land adjoining COLO to the east of Crawford Road – and contains one seasonal pond (# 1). The unit is located approximately 0.8 kilometers north of the Crawford Road (Route 637) crossing of Baptist Run (Figure 4). The current B-rank for this site is B2.

The seasonal pond is situated within an existing forest vegetation matrix. Two rare community types: 1) Loblolly Pine – Willow Oak / American Holly / Slender Spikegrass Association and 2) Sweetgum – Swamp Black Gum (Black Gum) / Cypress-swamp Sedge Association are found within Unit 1 (Table 8).

Sweetgum is the most abundant tree, with willow oak and red maple also common. A well-developed *Sphagnum* layer is present and a hummock at pond center supports dense fetterbush (*Leucothoe racemosa*). The watchlist (S3) damselfly, *Enallagma daeckii,* was observed here in 2000; however, no population size or viability rating for this species has been assigned. Because it is a highly mobile and widespread but very localized species, this damselfly could and likely does occur within nearby areas of suitable wetland habitat.

Table 8. Natural heritage resource summary for Unit 1 – Crawford Road Pond.

Element Name	Global / State Rarity Ranks	USFWS (Federal) Status	Virginia Status	Element Occurrence Rank
Coastal Plain Depression Wetland (Loblolly Pine – Willow Oak Type)	G? / S1	none	none	B
Coastal Plain Depression Wetland (Sweetgum – Swamp Black Gum (- Black gum) Type	G1G2 / S1	none	none	B
Enallagma daeckii (Attenuated bluet damselfly)	G4 / S3 (watchlist)	none	none	E

Unit objectives. (1) Maintain occurrences of existing natural heritage resources by maintaining habitat quality; (2) Enhance conditions so that the seasonal pond can support additional species associated with Coastal Plain Depression Wetland communities.

Management issues. Watershed protection is critical in Unit 1 for long-term maintenance of water quality, the pond hydrological balance and the natural communities present. The close proximity of Pond 1 to non-Park lands and Route 637 means an increased potential for sedimentation and contamination of both surface and ground waters. Road maintenance activities for Route 637 (paving, salting, patching, shoulder work, widening) have strong potential to directly affect biological resources within the seasonal pond.

During periods of high water, the seasonal pond merges with the drainage ditch along the west side of Route 637. Flora and fauna of the pond are therefore periodically subject to and potentially affected by runoff from Route 637.

The proximity to a state road and private residences increases the potential for unauthorized and inappropriate/incompatible public uses that could cause harm to sensitive wetland resources. In particular, mountain bikes and unauthorized trail construction could negatively impact sensitive resources within Unit 1.

Monitoring recommendations. Periodically assess water quality following rain events and highway maintenance (e.g. paving, de-icing chemical applications). Monitor for changes in land use and/or construction activities on the private landholdings within the unit. *Moderate priority.*

Monitor for incompatible public use due to the proximity of Pond 1 with a public roadway and adjacent private land, with particular attention to unauthorized activities such as off-trail mountain biking, horseback riding, and refuse dumping. *Moderate priority.*

Management recommendations. Develop contacts and agreements with, and provide seasonal pond resource information to VDOT on road maintenance issues so as to minimize effects on biota of seasonal pond communities within Pond 1. *Moderate priority.*

If indicated by monitoring results, control access and public use to deter types of use which are incompatible with preservation of seasonal pond resources. Conduct appropriate site security/law enforcement measures to ensure public and neighboring landowners are not negatively influencing seasonal pond resources. Develop and distribute information to neighboring private landowners about the significance of the Grafton Ponds Seasonal Pond Complex. *Moderate priority.*

Data gaps and research needs. Current influences and effects on seasonal pond water quality from the direct surface water connection to the Route 637 roadside ditch are unknown. Studies to determine if and to what degree nutrients, contaminants, and sediments are introduced to the pond from this source would inform future management actions.

Figure 6. Map of Unit 1 – Crawford Road Pond.

Unit 2 – Tour Road Swamp Pond

Unit information. The unit covers 25.5 ac (10.3 ha) and contains one seasonal pond (Pond 2), located on the north side of Tour Road, just west of the Beaverdam Creek bridge and east of the road intersection near Washington's Headquarters (Figure 5). Unit 2 supports a significant seasonal pond community occurrence with a mature forest canopy and predominantly native wetland vegetation. Although Van Alstine et al. (2001) reported that Tour Road Swamp Pond vegetation was consistent with Non-Riverine Wet Hardwood Forest communities, further analysis has classified this site as a Coastal Plain Depression Wetland community (Fleming, pers. comm. 2003) (Table 9). The wetland is elongate and has (apparently) human-enhanced inlet and outlet ditches at the western and eastern ends, respectively. During extreme high water events, Pond 2 likely connects functionally with Beaverdam Creek just to the east. Eastern mud minnows have been documented from this pond (Van Alstine et al. 2001). Pond 2 has a large population of marbled salamanders (*Ambystoma opacum*) and is a significant breeding site for this relatively common species (Hobson 2004). The assigned B-rank for the Unit 2 seasonal pond community is B4.

Unit 2 supports a relatively diverse flora, with more than twice as many taxa than the other three forested seasonal pond management units at COLO. A higher richness of herbaceous species contributes to this difference in floral diversity. Higher diversity at this site may be due to transport of propagules and nutrients associated with periodic influence from up- and down-stream sources.

Willow oak (*Quercus phellos*), loblolly pine (*Pinus taeda*), and sweetgum (*Liquidambar styraciflua*) are characteristic canopy dominants. Red maple (*Acer rubrum*) and black gum (*Nyssa sylvatica*) are common in the understory. American hornbeam (*Carpinus caroliniana*) and American elm (*Ulmus americana*) are abundant in the western portion. The relatively high diversity herbaceous assemblage includes cypress-swamp sedge (*Carex joorii*), graceful sedge (*Carex gracillima*), hop sedge (*Carex lupulina*), wood reedgrass (*Cinna arundinacea*), Virginia cutgrass (*Leersia virginica*), tall flat panic grass (*Panicum rigidulum* var. *rigidulum*), autumn bluegrass (*Poa autumnalis*), and marsh fern (*Thelypteris palustris* var. *pubescens*).

Table 9. Natural heritage resource summary for Unit 2 – Tour Road Swamp Pond.

Element Name	Global / State Rarity Ranks	USFWS (Federal) Status	Virginia Status	Element Occurrence Rank
Coastal Plain Depression Wetland (Loblolly Pine – Willow Oak Type)	G? / S1	none	none	B

Unit objectives. (1) Maintain occurrences of existing natural heritage resources by maintaining habitat quality; (2) Enhance conditions so that the seasonal pond can support additional species associated with Coastal Plain Depression Wetland communities.

Management issues. Watershed protection is critical for long-term maintenance of the pond hydrological balance and the natural communities present. The proximity of Pond 2 to Tour Road raises the possibility of sedimentation during future road improvements (relocation, widening, resurfacing). Such alterations to Tour Road could impact Pond 2 and potential effects should be considered during planning and construction of such improvements.

Unit 2 is currently infested with non-native highly invasive plants, specifically Japanese stilt grass (*Microstegium vimineum*) and Japanese honeysuckle (*Lonicera japonica*), both present in small patches near the pond. Proximity to Beaverdam Creek makes Unit 2 especially vulnerable to invasive species due to the potential for introductions via high water during flood events.

The proximity and flow connection to Beaverdam Creek creates the possibility that beavers could dam the outlet channel from Pond 2, potentially causing significant changes to pond hydrology (i.e. continuous vs. seasonal hydroperiods). Such alteration would likely result in drastic changes to vegetation, on-going presence of amphibian predators (fish), and the loss of seasonal pond communities.

Monitoring recommendations. Annually monitor the existing known populations of invasive plants as well as the effectiveness of any actions taken to control them. *High priority.*

Annually monitor for beaver activity in the vicinity of the eastern portion of Pond 2 and its outlet connection with Beaverdam Creek. *Moderate priority.*

Management recommendations. Japanese stilt grass in Unit 2 should be controlled immediately, given the likelihood of population expansion following widespread soil disturbance from Hurricane Isabel tree uprooting. Other invasive species including Japanese honeysuckle should be controlled if population expansion is indicated by monitoring results. *High priority.*

Coordinate internal Park road improvement and maintenance activities and identify alternatives that do not negatively affect seasonal pond water quality. Ensure the use of BMPs during construction or road maintenance activities within the Park whenever seasonal pond resources may be impacted. *Moderate priority.*

Develop and, as indicated by monitoring, implement a beaver management plan. *Moderate priority.*

Data gaps and research needs. Current influences and effects on seasonal pond water quality from the proximity to Tour Road are unknown. Studies to determine if and to what degree nutrients, contaminants, and sediments are introduced to the pond from Tour Road would guide future management actions.

The extent to which the biota and habitat conditions within Pond 2 are affected by the periodic connection (during high water) to Beaverdam Creek is unknown. Research could answer questions about nutrient and sediment inputs as well as introductions of various organisms from the creek.

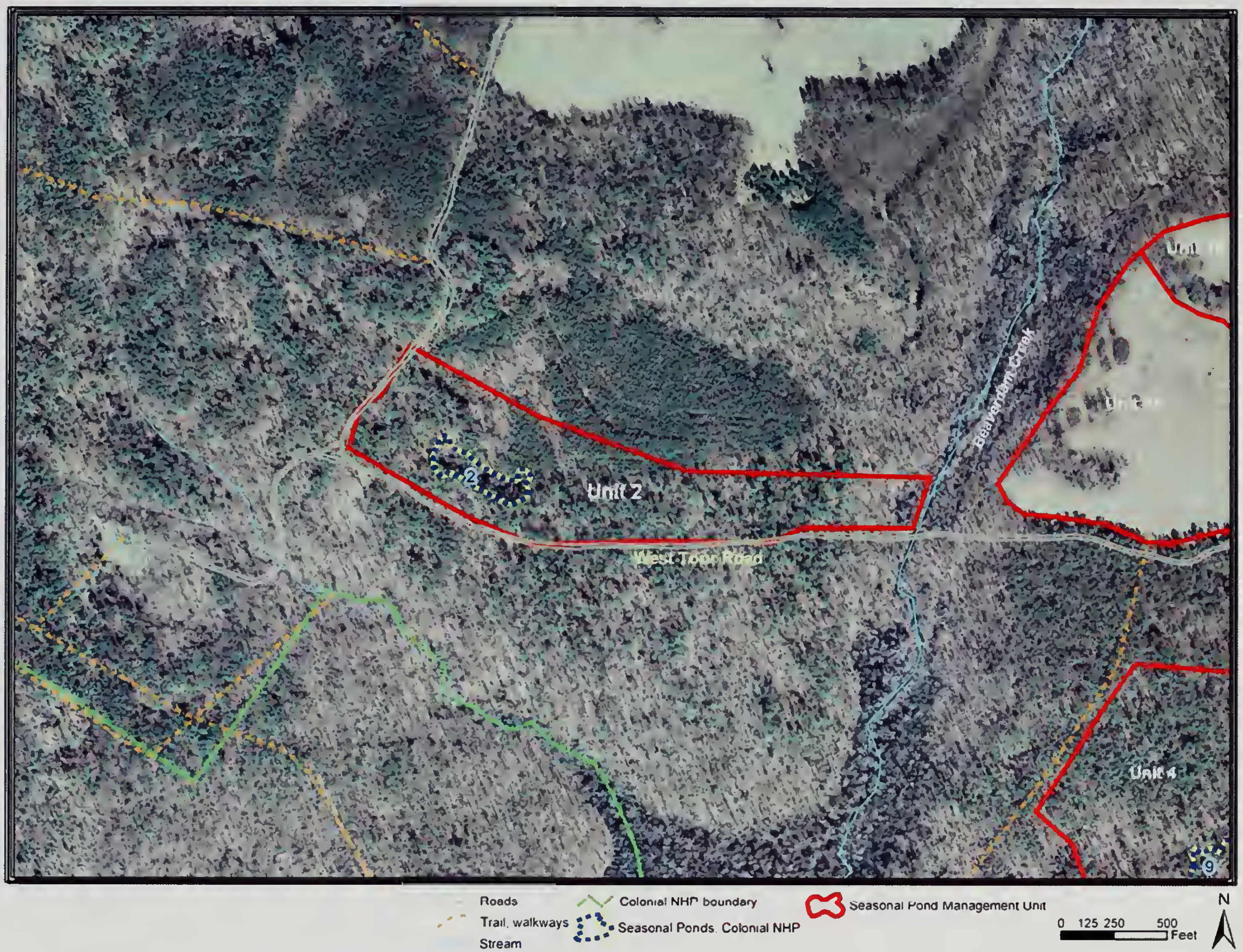

Figure 7. Map of Unit 2 – Tour Road Swamp Pond.

Unit 3 – Tour Road Field Ponds

Unit information. Unit 3 covers 65.1 ac (26.4 ha) and contains six seasonal ponds (3, 4, 5, 6, 7, and 8) located in COLO Field 10 on the north side of Tour Road, approximately 0.5 miles from the southernmost intersection of Tour Road and U.S. Route 17. Currently (2004), ponds are in an open field or early successional condition and dominated by herbaceous vegetation. The origin of Field 10 dates to the Colonial Period when pre-settlement forest was cleared to provide agricultural uses. Thus, for nearly four centuries, forest succession has been checked by tillage, grazing, haying, and (under NPS management) mowing for the purpose of preserving the historic colonial landscape. Beginning in winter of 2001-02, some areas of Field 10 supporting seasonal ponds were flagged by NPS staff and mowing was ceased. As of early March 2003, these areas remained unmowed. Due to long-term and continuous human use as agricultural fields, biotic communities existing within Field 10 are currently best characterized as anthropogenic rather than natural communities. As such, they have not been assigned a B-rank.

The open field seasonal ponds of Unit 3 support a contrasting flora to that of forested ponds and contain a combination of both native and non-native plant species including two globally-common (G5) state watchlist (S3) plants (Table 10). Relatively high species richness and herbaceous biomass exist due to increased light and low competition in these open habitats. Non-native plants are present and common, but summer and fall flora are composed predominantly of native species. Tall flat panic grass (*Panicum rigidulum*), smartweeds (*Polygonum* spp.), and rushes (*Juncus* spp.) are prominent.

The Unit 3 ponds currently support no known rare animal species. However, they provide breeding and foraging habitat for large numbers of common animals such as chorus frogs – species which require wetland habitats such as seasonal ponds. Amphibians, particularly Ambystomid salamanders, are known to travel from upland habitats to nearby ponds at various times in their life cycle. Unit 3 ponds are well within the dispersal range of Ambystomids using nearby forested habitats and the seasonal ponds in Unit 4 just to the south (Chazal and Niewiarowski 1998; Gibbons and Semlitsch 1991).

Table 10. Natural heritage resource summary for Unit 3 – Tour Road Field Ponds.

Element Name	Global / State Rarity Ranks	USFWS (Federal) Status	Virginia Status	Element Occurrence Rank
Axonopus furcatus (big carpet grass)	G5 / S3 (watchlist)	none	none	E
Eleocharis tenuis var. *verrucosa* (slender spikerush)	G5 / S3 (watchlist)	none	none	E

Unit objectives. (1) Maintain occurrences of natural heritage resources and restore functional natural communities and habitat for rare species of plants and animals; (2) Maintain both the populations of watchlist plants and historic field landscape by continuing the existing mowing regime in Subunit 3a (that portion of Unit 3 containing Pond 3).

Management issues. Three specific management issues pertain to Unit 3. These are:
1. Promote forest succession to restore natural communities in the eastern portion of the unit (Subunit 3b);
2. Maintain the western portion (Subunit 3a) in grass / shrubland, with eventual conversion from cool season exotic grasses to native warm season grasses;
3. Control invasive non-native plant species.

The two watchlist plants known from Unit 3 require open field conditions created by mowing (or some other means of disturbance such as fire) to persist. However, the Unit 3 fields also represent an opportunity to restore natural communities by permanently halting mowing and allowing the process of succession to create a mosaic of forested seasonal ponds and upland pine-oak forest. In this second scenario, forested Coastal Plain Depression Wetland natural communities would develop but the two state watchlist plants currently present in the open field ponds would likely cease to occur due to loss of open field conditions. This is a case where a choice must be made between two contrasting management directions. Either choice will result in the perpetuation of some natural heritage resources; however, neither can result in the conservation of both seasonal pond natural communities and the open field plant species. From the perspective that the rare community has a high S-rank (S1) and the watchlist plants are globally common (G5), it is preferable in this case to promote restoration (through natural succession) of the forested seasonal ponds, tolerating the probable loss of the two plant species within Subunit 3b.

Pond 3 as well as all of Subunit 3a should be maintained in an open field condition. Doing so will attain three compatible objectives: (1) retention of habitat for two watchlist plant species currently found at this location; (2) preservation of the historic post-settlement landscape as viewed from Tour Road; (3) maintenance of habitat for grassland-dependant wildlife species. Conversion from the cool season, exotic grass species currently present in this area to native warm season grasses such as little bluestem (*Schizachyrium scoparium*) and Indiangrass (*Sorghastrum nutans*) will have added benefits for grassland bird, mammal, and invertebrate species. Finally, retaining this portion of Unit 3 in open grassland will maintain habitat for amphibian species known to prefer open, herbaceous wetlands. In particular, the newly discovered species for Virginia, *Pseudacris nigrita* (southern chorus frog), which is known from nearby Pond 12 in Unit 5, may benefit from the continued maintenance of Pond 3 as an open field seasonal wetland.

Unit 3 seasonal ponds are threatened to some extent by non-native invasive plant species which compete with and can exclude native plants, resulting in undesirable change to vegetation composition and habitat structure. A number of invasive plant species are known from the Unit 3 field wetlands, including velvet-grass (*Holcus lanatus*), meadow fescue (*Lolium pratense*), Bermuda grass (*Cynodon dactylon*), and sheep-sorrel (*Rumex acetosella*). None of these plants, however, are considered to be highly invasive species (VDCR 2004). Still, if mowing is permanently halted in portions of Unit 3, it is likely that invasive plants will be favored and could – at least temporarily – become dominant components of the developing successional community.

Monitoring recommendations. Due to the known occurrence of non-native invasive plants in Unit 3, annual monitoring of invasive species presence, abundance, and distribution is needed. *High priority.*

Ceasing field maintenance in Subunit 3b will allow forest succession to proceed, altering vegetation structure and composition, and likely resulting in the appearance of species new to this unit. Therefore, a monitoring program is needed with periodic (annual to biennial) surveys of pond vegetation and fauna within the setting of natural succession as ponds transition from open field structure to young forest. The development of forest vegetation could also decrease soil wetness and hydroperiod in the seasonal ponds of Subunit 3b) due to increased transpiration rates associated with forest vegetation. Monitoring pond hydroperiods will provide insight into the potential value of different ponds in Subunit 3b to various species of fauna. *Lower priority.*

Monitor Unit 3 ponds for possible presence of southern chorus frog. *High priority.*

Monitor deer herbivory impacts on developing vegetation within the Subunit 3b restoration area to assess deer influences on community development as the field succeeds to forest. *Moderate priority.*

Management recommendations. <u>The five ponds in Subunit 3b (4, 5, 6, 7, 8) and their surrounding adjacent uplands should be allowed to undergo natural succession in order to restore Coastal Plain Depression Wetland natural communities</u>. These five ponds are located in the northeast portion of Unit 3, shown on Figure 6 within Subunit 3b. Ceasing mowing in this area will allow the process of succession to proceed, producing forest vegetation and eventually restoring natural forested seasonal pond habitats which will, in turn, provide potential habitat for numerous rare species. *High priority.*

During succession to forested seasonal pond communities and surrounding forested uplands, invasive species in Subunit 3b should be controlled if monitoring indicates population expansion. Highly invasive species such as Japanese honeysuckle, Japanese stilt-grass and tree-of-heaven (*Ailanthus altissima*) should be controlled since their presence will interfere with the desired establishment and development of native species. *High priority.*

Pond 3 and its surrounding field habitat adjacent to Tour Road should be maintained as open field habitat either by mowing, burning, or a combination of these two methods. This approach will allow the continued existence of two state watchlist plant species which require open conditions. Further, this approach will be compatible with the high priority NPS objective of preserving/maintaining historic landscapes at COLO and also benefit grassland-dependant animals. *High priority.*

Manage Subunit 3a for improved benefits to grassland birds. While Field 10 vegetation currently contains some native warm season grasses (NWSG) – mostly broomsedge (*Andropogon virginicus*) – it also contains considerable fescue which provides little or no positive habitat values for native wildlife. Watts (2000) has recommended reserving field patches of 14.8 acres or larger at COLO for grassland bird habitat management. Therefore, Subunit 3a, covering

approximately 30 acres, is a likely candidate for management that provides basic habitat requirements of grassland bird species. *High priority.*

Non-native invasive plants including Bermuda grass (*Cynodon dactylon*), velvet grass (*Holcus lanatus)*, and meadow fescue (*Lolium pratense*) should be controlled and NWSG established (using readily-available guidelines for establishing NWSG and native forbs). Once established, NWSG can be maintained by annual mowing/haying in mid-June to mid-July. Mowing in early summer will allow ample opportunity for the two watchlist plants associated with Pond 3 to reproduce following mowing. Big carpet grass flowers and fruits from July to October, while slender spikerush flowers and fruits from June through September (Radford et al. 1968). Burning could be used in conjunction with or as an alternative to mowing, with fire applied every one to three years. Ideal timing of burning to favor NWSG and promote high diversity grassland is around the first week of April (Capel 1995). *Moderate priority.*

As feasible and recommended by the COLO Fire Management Plan (Raeburn, under development), implement prescribed fire management to achieve vegetation management goals in Subunit 3a. As forest succession proceeds in Subunit 3b, begin using prescribed fire to create and maintain an open forest structure that benefits seasonal pond resources including both known and potential occurrences of rare species. *Moderate priority.*

Data gaps and research needs. Information on the role of fire in maintaining seasonal pond communities and as a component of the successional process following major disturbance (as from hurricanes or ice storms) is needed and would inform efforts to restore seasonal pond natural communities from old fields within Subunit 3b.

Research involving periodic surveys of rare animals would provide insight into the value of early-successional seasonal pond forest habitats to rare species known from Coastal Plain Depression Wetlands on the Grafton Plain.

As restoration plans in Unit 3 begin, status of resources in both Subunits should be monitored carefully. Since little technical information is available on restoring seasonal pond communities, successional stages for Ponds 4, 5, 6, 7, and 8 should be monitored and vegetation composition assessed periodically to determine if desired communities are developing. Likewise, since no technical information is available for managing populations of the two watchlist plants to be maintained (using mowing and/or fire) in Sub-unit A, periodic checks of these species occurrences should be made to assess their status and response to proposed management regimes.

Figure 8. Map of Unit 3 – Tour Road Field Ponds.

Unit 4 – Earthwork Ponds

Unit information. Unit 4 covers 75. 6 ac (30.6 ha) and contains two seasonal ponds (9 and 10) within a forested matrix located in the southeastern portion of the Yorktown Unit, south of Tour Road. The ponds are accessed by walking south from Tour Road about 400 m along a woods road / trail, then heading eastward and uphill through forest about 150 m. The ponds are situated on the upper slope of a low gradient drainage of Beaverdam Creek and border an area modified by Revolutionary War earthworks. The hydrology of both ponds may be influenced by these earthworks.

Both the Loblolly Pine – Willow Oak / American Holly / Slender Spikegrass Association and the Sweetgum – Swamp Black Gum (- Black Gum) / Cypress-swamp Sedge Association are found in the seasonal ponds of Unit 4 (Table 11). Pond 10 is the smaller of the two wetlands and is dominated by sphagnum moss with an intermittent outlet to the southeast. This pond currently supports the state threatened (S1S2) Mabee's salamander (*Ambystoma mabeei*) (Van Alstine et al. 2001). The B-rank for the site is B2.

Table 11. Natural heritage resource summary for Unit 4 – Earthwork Ponds.

Element Name	Global / State Rarity Ranks	USFWS (Federal) Status	Virginia Status	Element Occurrence Rank
Coastal Plain Depression Wetland (Loblolly Pine – Willow Oak Type)	G? / S1	none	none	B
Coastal Plain Depression Wetland (Sweetgum – Swamp Black Gum (- Black Gum) Type	G1G2 / S1	none	none	B
Ambystoma mabeei (Mabee's salamander)	G4 / S1S2	none	threatened	C

Unit objectives. (1) Maintain occurrences of natural heritage resources and seasonal pond natural communities that provide habitat for rare species; (2) Maintain the population of Mabee's salamanders and enhance habitat conditions to allow its possible expansion; (3) Maintain habitat connections to allow continued functioning of the local metapopulation of Mabee's salamanders centered within the Grafton Ponds Natural Area Preserve to the south.

Management issues. The primary management issue for Unit 4 is protecting the existing Mabee's salamander population. This species also occurs in nearby seasonal ponds within the Grafton Ponds Natural Area Preserve. Mabee's salamanders are 3-3 7/8" (7.6-10 cm) long, stout with narrow head and short tail, deep brown to black above with indistinct light flecks, and lighter sides with many whitish flecks. The belly is brown, with few flecks. Breeding occurs from January to March in acidic, fishless ponds in or near forest habitats. Single eggs or small egg groups are attached to water plants or submerged twigs. Larvae transform in May and are 2 3/8" (6 cm) long when they move from their aquatic environments (seasonal ponds) to their new

terrestrial habitats. Range is the coastal plain of southeast Virginia south across North Carolina and into South Carolina. The species was first collected in 1923 by W. B. Mabee.

As with all Ambystomids (mole salamanders), Mabee's salamanders dig tunnels and remain underground most of their lives. After early spring rains they tend to congregate in temporary pools and ponds to carry out their courtships and deposit eggs. Eggs are usually laid in small groups, or singly, floating at the surface of the water or submerged and attached to various objects. Finding specimens at any time other than breeding period is largely a matter of chance.

Terrestrial home ranges of adult Ambystomids may extend at least 300 m and up to perhaps 800-1200 m (Semlitsch 1981; Chazal and Niewiarowski 1998; Hobson pers. comm. 2002). Using these guidelines, Unit 4 boundaries were drawn to provide for long-term viability of the Mabee's salamander population by protecting areas adjacent to the ponds that represent likely dispersal, immigration, and emigration routes. The Unit 4 Mabee's salamander population may interact with adjacent populations and could benefit from additional protection of movement routes.

The potential effects of Hurricane Isabel-related tree falls on salamander populations should be a focus of monitoring efforts. Increased quantities of downed woody debris could benefit Mabee's and other amphibians, while increased light levels and surface temperatures from the recent canopy reduction could have negative effects.

A second specific issue for Unit 4 is its proximity to private residences in the Edgehill neighborhood to the southeast. This proximity increases the potential for unauthorized and inappropriate/incompatible public uses that could cause harm to sensitive wetland resources. In particular, mountain bikes and unauthorized bike trail construction could negatively impact resources in Unit 4.

Monitoring recommendations. Long-term monitoring is recommended for the significant natural communities at these ponds, for occurrences of invasive species, and for the Mabee's salamander population. *High priority.*

Management recommendations. A management priority for Unit 4 is to assure protection of the Pond 10 Mabee's salamander breeding habitat. Disturbances from canopy-affecting influences, including the recent (September 2003) windthrows from Hurricane Isabel, may affect the breeding site, although it is unclear whether such effects are cumulatively either positive or negative. Salamanders use non-breeding habitat (the adjacent uplands) for shelter and feeding. Any post-hurricane actions (such as salvage logging, aesthetic "cleanup" operations) that remove downed woody material should be avoided (Pague and Mitchell 1991). Likewise, the habitat connections between Unit 4 ponds (9 and 10) and Unit 5 ponds (11 and 12), as well as the connective habitat between Unit 4 and the Grafton Ponds Natural Area Preserve to the south should be protected from land use alterations such as road or trail construction or other visitor facility placement that might impede or destroy travel corridors. *High priority.*

Data gaps and research needs. Although little information is available on the terrestrial ecology and life history of Mabee's salamander, other Ambystomids are known to travel considerable distances away from breeding sites (Chazal and Niewiarowski 1998; Gibbons and

Semlitsch 1991; Pague and Mitchell 1991). It is possible – perhaps likely – that the COLO occurrence is part of a larger "metapopulation", with interbreeding and gene exchange among discrete but linked populations. If the metapopulation concept holds true in the case of Mabee's salamanders on the Grafton Plain, then resource managers should focus on maintaining the connective habitats between populations, as well as the seasonal wetlands known to be important for breeding. Further studies are necessary on Mabee's salamander life history, habitat requirements for both breeding and non-breeding sites, individual as well as genetic movement, genetic status, and relationship of the population at COLO and the populations inhabiting seasonal ponds on adjacent lands.

Study of the seasonal presence / absence of fish (potential Ambystomid predators) in Unit 4 ponds could provide an explanation of the presence of Mabee's salamanders at this location within COLO.

Studies of the effects of increased light gaps and down woody debris caused by Hurricane Isabel on Mabee's salamander abundance and distribution at COLO would inform management efforts.

Experimental use of prescribed fire to increase forest understory openness and encourage herbaceous groundcover plant development – while retaining a full overstory canopy – with habitat conditions known to favor Mabee's salamander carefully monitored, would provide useful information for refining fire management recommendations at COLO.

Unit 4 ponds are in close proximity to the Grafton Ponds Natural Area Preserve supporting additional rare animal species. It is therefore recommended that periodic intensive faunal assessments be conducted at Ponds 9 and 10 to detect/confirm rare species presence.

Given the proximity to other seasonal ponds on the Grafton Plain, it is likely that ponds in Unit 4 may be the first to be recolonized by various species of plants and animals known from and existing in metapopulation on the Grafton Complex but not currently occurring at COLO. Such recolonization is likely only if required habitat conditions are restored. Unfortunately, it is not well known which conditions are required to provide habitat conditions conducive for each species that could potentially occur (see Table 6); likewise, it is not clear which management techniques would be most appropriate for restoring such conditions. However, a likely process to focus on is fire, as simulated through prescribed burning, which could be used to maintain forested conditions but alter structure such that forest floor thickness is reduced, understory and midstory vegetation layers are reduced or removed, and herbaceous groundcover plants are increased. As indicated by the Conceptual Ecological Model (Figure 4), seasonal ponds with increased openness and sufficiently long hydroperiods are those that provide the highest quality habitat for and could support species such as Mabee's salamander and Harper's fimbry. Research to evaluate the use of prescribed fire as a management tool for improving habitat conditions for these and other species on the Grafton Plain would fill a large data gap and represents a current high priority research need.

Figure 9. Map of Unit 4 – Earthwork Ponds.

Unit 5 – Siege Lane Ponds

Unit information. Unit 5 covers 13.0 ac (5.3 ha) and contains two seasonal ponds (11 and 12) within a forested area in the far southeast corner of the Yorktown Unit and adjacent to the Edgehill subdivision. Unit 5 lies just north of the Grafton Ponds Natural Area Preserve, owned by the City of Newport News and co-managed with DCR-DNH. Canopy trees at the two ponds are similar and include red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), willow oak (*Quercus phellos*), loblolly pine (*Pinus taeda*), and blackgum (*Nyssa sylvatica*). Pond 11 contains both the Loblolly Pine – Willow Oak / American Holly / Slender Spikegrass association and the Sweetgum – Swamp Black Gum -Black Gum / Cypress-Swamp Sedge association, and also supports overcup oak (*Quercus lyrata)*. Pond 12 supports the Sweetgum – Swamp Black Gum -Black Gum / Cypress-Swamp Sedge association. The B-rank for seasonal pond communities within Unit 5 is B2 (Table 12).

Table 12. Natural heritage resource summary for Unit 5 – Siege Lane Ponds.

Element Name	Global / State Rarity Ranks	USFWS (Federal) Status	Virginia Status	Element Occurrence Rank
Coastal Plain Depression Wetland, Loblolly Pine – Willow Oak Type (Pond 11)	G? / S1	none	none	B
Coastal Plain Depression Wetland, Sweetgum – Swamp Black Gum (- Black Gum) Type (Pond 11)	G1G2 / S1	none	none	B
Coastal Plain Depression Wetland, Sweetgum – Swamp Black Gum (- Black Gum) Type (Pond 12)	G1G2 / S1	none	none	B
Pseudacris nigrita (southern chorus frog) (Pond 12)	G5 / S2?	none	none	E

Unit objectives. (1) Maintain occurrences of existing natural heritage resources by maintaining habitat quality; (2) Enhance habitat conditions such that Unit 5 seasonal ponds begin supporting other rare species associated with Coastal Plain Depression Wetland communities on the Grafton Plain.

Management issues. Issues for ponds 11 and 12 within Unit 5 include water quality protection and incompatible public uses associated with the proximity to the adjacent Edgehill neighborhood. In particular, unauthorized trail construction and use by bicycles, all terrain vehicles, or heavy foot traffic in or near ponds has potential for causing negative impacts to resources.

Potentially negative influences from the nearby suburban area include well-water withdrawals, inputs of nutrients from septic systems, and debris dumping – all of which could negatively impact water quality and pond hydrological characteristics. Pond 11 is directly adjacent to backyards of homes in the Edgehill neighborhood homes and has recently been the site of trash and debris dumping.

Monitoring recommendations. The rare natural communities documented at Ponds 11 and 12 should be monitored every one to two years to observe general conditions, forest health, and evidence of human activities / influences. In particular, monitoring for illegal dumping of refuse in Pond 11 is needed due to an established pattern of use. *Moderate priority.*

A population of the state-rare animal, southern chorus frog, was discovered in 2003 at Pond 12 and should be monitored to ascertain number of individuals and status on at least a biennial basis. *High priority.*

Management recommendations. Trash and debris in Pond 11 should be removed. Landowner contacts should be made to discourage future dumping of trash, construction debris, old Christmas trees, etc. Staff from COLO could work closely with resource managers at the City of Newport News (CNN) to increase water quality protection in Unit 5, in particular by examining contents of nearby dumped material on CNN property and discussing its eventual removal. Enforce existing local, state, and federal wetland and watershed protection laws, as well as listed species protection laws. *High priority.*

Data gaps and research needs. Current influences and effects on seasonal pond water quality from the surface- and ground-water connections to Siege Lane and nearby residences are unknown. Studies to determine if and to what degree nutrients, contaminants, and sediments are introduced to Unit 5 seasonal ponds from these sources would guide future management actions.

Unit 5 ponds are in close proximity to the Grafton Ponds Natural Area Preserve supporting additional rare animal species. It is therefore recommended that periodic intensive faunal assessments be conducted at Ponds 11 and 12 to detect/confirm their presence.

Given the proximity to other seasonal ponds on the Grafton Plain, it is likely that ponds in Unit 5 may be the first to be recolonized by various species of plants and animals known from and existing in metapopulation on the Grafton Complex but not currently occurring at COLO. Such recolonization is likely only if required habitat conditions are restored. Unfortunately, it is not well known which conditions are required to provide habitat conditions conducive for each species that could potentially occur (see Table 6); likewise, it is not clear which management techniques would be most appropriate for restoring such conditions. However, a likely process to focus on is fire, as simulated through prescribed burning, which could be used to maintain forested conditions but alter structure such that forest floor thickness is reduced, understory and midstory vegetation layers are reduced or removed, and herbaceous groundcover plants are increased. As indicated by the Conceptual Ecological Model (Figure 4), seasonal ponds with increased openness and sufficiently long hydroperiods are those that provide the highest quality habitat for and could support species such as Mabee's salamander and Harper's fimbry. Research to evaluate the use of prescribed fire as a management tool for improving habitat conditions for these and other species on the Grafton Plain would fill a large data gap and represents a current high priority research need.

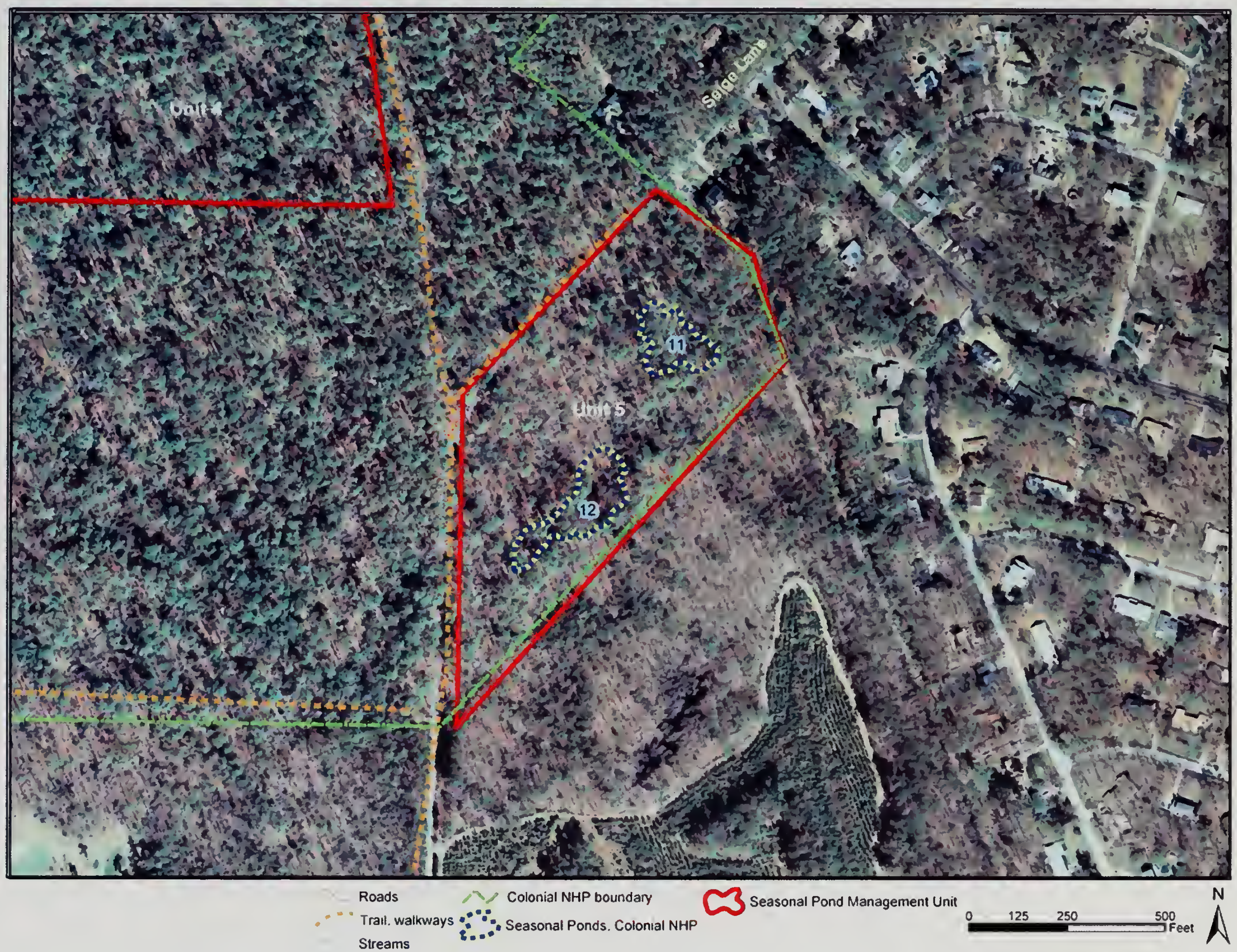

Figure 10. Map of Unit 5 – Siege Lane Ponds.

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APPENDICES

A. Selected Photos of the Seasonal Pond Natural Area at Colonial National Historical Park

B. Rarity and Biodiversity Rank Explanations

C. Pertinent Federal and State Natural Resource Laws

D. Definition of the Term "Seasonal Pond"

E. Obligate and Facultative Wetland Plants Potentially Found in Seasonal Ponds at Colonial National Historical Park

Appendix A: Selected Photos of the Seasonal Pond Natural Area at Colonial National Historical Park

Unit 1 – Crawford Road Pond

Figure A-1. Pond #1 within Unit 1 along Crawford Road, Colonial National Historical Park. (April 13, 1999. Photographer: Kathleen M. McCoy)

Figure A-2. A damselfly (*Enallagma daeckii*) (female), on the DCR-DNH watchlist of rare animal species documented as occurring in the vicinity of Pond #1 within Unit 1. (Photographer: Steven M. Roble).

Unit 2 – Tour Road Swamp Pond

Figure A-3. Pond #2 within Unit 2, along Tour Road at Colonial National Historical Park.. (April 19, 2000. Photographer: Nancy E. Van Alstine).

Figure A-4. Japanese stilt-grass. This highly invasive plant warrants intensive monitoring and control within the Seasonal Pond Natural Area at COLO.

Unit 3 – Tour Road Field Ponds

Figure A-5. Pond #3 within Unit 3, north of Tour Road in Colonial National Historical Park. (March 2000. Photographer: Kristen Gounaris).

Figure A-6. Upland chorus frog (*Pseudacris ferriarum*) captured in Unit 3; a common animal in Virginia that requires seasonal wetland habitats. (March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-7. Big carpet grass (*Axonopus furcatus*) (broad-leaved grass in foreground of photo), on the DCR-DNH watchlist of rare plant species and occurring within Unit 3 at COLO. (Photographer: Nancy E. Van Alstine).

Figure A-8. Slender spikerush (*Eleocharis tenuis* var. *verrucosa*) (the fine-leaved graminoid in middle of photo), on the DCR-DNH watchlist of rare plant species and occurring within Unit 3 at COLO. (Photographer: Nancy E. Van Alstine).

Unit 4 – Earthwork Ponds

Figure A-9. Earthworks on southeast side of Pond #9 within Unit 4. (March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-10. Pond #9 within Unit 4. (March 4, 2003. Photographer: Charles D. Rafkind.

Figure A-11. Pond #10 within Unit 4, home to the Mabee's salamander population at COLO's Seasonal Pond Natural Area. (March 4, 2003. Photographer: Charles D. Rafkind.

Figure A-12. Mabee's salamander egg (single) at Pond #10. (March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-13. Mabee's salamander (*Ambystoma mabeei*) at Pond #10 within the COLO Seasonal Pond Natural Area. (Photographer: Kathleen M. McCoy).

Figure A-14. Mabee's salamander (*Ambystoma mabeei*). Photo taken at the nearby Grafton Ponds Natural Area Preserve. (Photographer: Steven M. Roble).

Unit 5 – Siege Lane Ponds

Figure A-15. Pond #11 within Unit 5 of the COLO Seasonal Pond Natural Area. (March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-16. View looking northward from Pond #11 at backyards of adjacent house lots of the Edgehill subdivision. (March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-17. Christmas tree dumped on NPS land just north of Pond #11.
(March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-18. Woody debris and construction waste dumped on lands of the City of Newport News, just upslope and east of Pond #11. (March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-19. Standard boundary sign for Colonial National Historical Park. Protection of seasonal pond resources would be increased if new, larger signs designating the Seasonal Pond Natural Area at COLO were placed along park boundaries near seasonal pond management Units 1 and 5. (March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-20. Anterior and dorsal views of spotted turtle (*Clemmys guttata*) collected from Pond #12 within Unit 5 on March 4, 2003. (Photographer: Charles D. Rafkind).

Figure A-21. Pond #12 and spotted turtle (*Clemmys guttata*). Shown are Chris Hobson, DCR-DNH Zoologist (left) and R.K. Myers, DCR-DNH Stewardship Manager. (March 4, 2003. Photographer: Charles D. Rafkind).

Figure A-22. Southern chorus frog (*Pseudacris nigrita*), a rare animal (G5 S2?) for Virginia and documented for Pond #12 of Unit 5 at the COLO Seasonal Pond Natural Area in 2003. (Photographer: Chris Hobson).

Appendix B: Rarity and Biodiversity Ranking Explanations

Each of the significant natural features (species, community type, etc.) monitored by DCR-DNH is considered an element of natural diversity, or simply an **element**. Each element is assigned a rank that indicates its relative rarity on a five-point scale (1 = extremely rare; 5 = abundant; Table 1). The primary criterion for ranking elements is the number of occurrences, i.e., the number of known distinct localities or populations. Also of great importance is the number of individuals at each locality or, for highly mobile organisms, the total number of individuals. Other considerations include the condition of the occurrences, the number of protected occurrences, and threats. However, the emphasis remains on the number of occurrences, so that ranks essentially are an index of known biological rarity. These ranks are assigned both in terms of the element's rarity within Virginia (its State or S-rank) and the element's rarity over its entire range (its Global or G-rank). Subspecies and varieties are assigned a Taxonomic (T-) rank in addition to their G-rank. Taken together, these ranks give a concise picture of an element's rarity. For example, a designated rank of G5/S1 indicates an element which is abundant and secure range-wide, but extremely rare in the state. Ranks for community types are provisional, or in many cases lacking, due to ongoing efforts by the Natural Heritage network to classify community taxa. These global and state rarity ranks used by DCR-DNH are not legal designations, and they are continuously updated to reflect new information.

Definition of Natural Heritage state rarity ranks. Global ranks are similar to state ranks, but refer to a species' range-wide status. Note that GA and GN are not used and GX means extinct. Sometimes ranks are combined (e.g. S1S2) to indicate intermediate or somewhat unclear status. Elements with uncertain taxonomic validity are denoted by the letter Q, after the global rank. Ranks for most community types have not been generated due to ongoing community classification efforts. These ranks should not be interpreted as legal designations.

S1 Extremely rare; usually 5 or fewer occurrences in the state; or may have a few remaining individuals; often especially vulnerable to extirpation.

S2 Very rare; usually between 5 and 20 occurrences; or few occurrences with many individuals; often susceptible to becoming endangered.

S3 Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.

S4 Common; usually more than 100 occurrences, but may be fewer with many large populations; may be restricted to only a portion of the state; usually not susceptible to immediate threats.

S5 Very common; demonstrably secure under present conditions.

SA Accidental in the state.

SH Historically known from the state, but not verified for an extended period, usually more than 15 years; this rank is used primarily when inventory has been attempted recently.

SN Regularly occurring migrants or transient species which are non-breeding, seasonal residents. (Note that congregation and staging areas are monitored separately).

SU Status uncertain, often because of low search effort or cryptic nature of the element.

SX Apparently extirpated from the state

S_? Rank uncertain

Element occurrences. The spot on the landscape that supports a natural heritage resource is an *element occurrence.* Occasionally, separate but nearby locations of a species or community element are treated as subpopulations (species) or sub-occurrences (community) of the same occurrence due to factors such as the probability of gene flow or hydrologic linkage. Information on the location and quality of these element occurrences is computerized within the BIOTICS conservation data system, and additional information is recorded on maps and in manual files.

Element occurrence ranks. In addition to ranking each element's rarity, each element occurrence is ranked to differentiate large, outstanding occurrences from small, vulnerable ones. In this way, protection efforts can be aimed not only at the rarest elements, but at the best examples of each. Species occurrences are ranked in terms of quality (size, vigor, etc.) of the population; the condition (pristine to disturbed) of the habitat; the viability of the population; and the defensibility (ease or difficulty of protecting) of the occurrence. Community occurrences are ranked according to their size and overall natural condition. These *element occurrence ranks* range from A (excellent) to D (poor). Sometimes these ranks are combined to indicate intermediate or somewhat unclear status, e.g. AB or CD, etc. In a few cases, especially those involving cryptic animal elements, field data may not be sufficient to reliably rank an occurrence. In such cases a rank of E (extant) may be given. Element occurrence ranks reflect the current condition of the species' population or community. A poorly-ranked element occurrence can, with time, become highly-ranked as a result of successful management or restoration.

Biodiversity ranks. Element occurrence ranks form the basis for ranking the overall significance of sites. Site *biodiversity ranks* (B-ranks) are used to prioritize protection efforts and are defined as follows:

B1 Outstanding Significance: only site known for an element; an excellent occurrence of a G1 species; or the world's best example of a community type.

B2 Very High Significance: excellent example of a rare community type; good occurrence of a G1 species; or excellent occurrence of a G2 or G3 species.

B3 High Significance: excellent example of any community type; good occurrence of a G3 species.

B4 Moderate Significance: good example of a community type; excellent or good occurrence of state-rare species.

B5 General Biodiversity Significance: good or marginal occurrence of a community type or state-rare species.

Note: sites supporting rare subspecies or varieties are considered slightly less significant than sites supporting similarly ranked species.

Explanation of Federal and State Categories

The U.S. Fish and Wildlife Service (USFWS) is responsible for the listing of endangered and threatened species under the Endangered Species Act of 1973, as amended. Federally listed species (including subspecific taxa) are afforded a degree of legal protection under the Act, and, therefore, sites supporting these species need to be highlighted. USFWS also maintains a review listing of potential candidate endangered and threatened taxa. Table 2 defines the various status categories used by USFWS and followed in this report. The status category of candidate species is based on the Service's current level of knowledge about the biological vulnerability of and threats to a species.

USFWS species status codes with abbreviated definitions.

LE Listed endangered

LT Listed threatened

PE Proposed to be listed as endangered

PT Proposed to be listed as threatened

C Candidate (formerly category 1): status data supports listing of taxon as endangered or threatened, but listing has been delayed by pending proposals of higher priority taxa.

In February 1996 the USFWS revised its categories for the candidate list in the following manner: Taxa formerly considered as 'Category 1' candidates for listing are now considered as 'Candidate'. Taxa formerly considered as 'Category 2' (C2) candidates are no longer being maintained by the Service as Candidate or Status Review taxa. The Service has suggested that such taxa be considered as 'Species of Concern' (SOC) or 'Species at Risk,' neither of which has official status. The Virginia Field Office of the USFWS maintains a list of these SOC which includes all taxa globally ranked as G1-G2 (Eric Davis, pers. comm.). Taxa formerly considered as 'Category 3' candidates are no longer being maintained by the Service. This included taxa for which the Service had persuasive evidence of extinction (3A); that did not represent distinct entities meeting the Act's definition of 'species' (3B); or that had proven to be more abundant or widespread, or not subject to any identifiable threat (3C).

Appendix C: Pertinent Federal and State Natural Resource Laws

In Virginia, two acts have authorized the creation of official state endangered and threatened species lists. One act (section 29.1-563 through 570, Code of Virginia), administered by the Virginia Department of Game and Inland Fisheries (DGIF), authorizes listing of fish and wildlife species, not including insects. The Endangered Plant and Insect Species Act, (section 3.1-1020 through 1030, Code of Virginia), administered by the Virginia Department of Agriculture and Consumer Services (VDACS), allows for listing of plant and insect species. In general, these acts prohibit or regulate taking, possessing, buying, selling, transporting, exporting, or shipping of any endangered or threatened species appearing on the official lists. Species protected by these acts are indicated as either listed endangered (LE) or listed threatened (LT). Species under consideration for listing are indicated as candidates (C). In addition DGIF has created an informal category of Special Concern (SC) for animals that merit special attention; this is an unprotected status.

Listing of Federal Natural Resource Laws

LEGISLATION	CITATION	RESPONSIBLE AGENCY
Presidential Order on Introduction of Exotic Species	Executive Order # 11987	Office of the President
U.S. Noxious Weed Law	7 USC 2802-2814	U.S. Department of Agriculture (USDA)
U.S. Clean Water Act	33 USC 1344	U.S. Army Corps of Engineers (ACOE), U.S. Environmental Protection Agency (EPA)
U.S. Rivers & Harbors Act	33 USC 404	ACOE
U.S. Coastal Zone Management Act	16 USC 1451-1464	National Oceanic & Atmospheric Administration (NOAA)
U.S. Anadromous Fish Conservation Act	16 USC 757a-757g	National Marine Fisheries Service (NMFS)
Navigable Waters of the U.S.	14 USC 2	U.S. Coast Guard (USCG)
U.S. Clean Air Act	42 USC 7401-7671q	EPA
National Environmental Policy Act	42 USC 4321-4307d	all Federal agencies
Lacey Act (exotics)	18 USC 42	U.S. Department of Interior (DOI)
U.S. Endangered Species Act	16 USC 1531-1544	U.S. Fish & Wildlife Service (FWS), NMFS

U.S. Fish & Wildlife Coordination Act	16 USC 661-668s	many
U.S. Migratory Bird Treaty Act	16 USC 701-712	FWS
U.S. Aquatic Nuisance Prevention & Control Act	16 USC 4701-4751	FWS, NMFS

Listing of State Natural Resource Laws

LEGISLATION	CITATION	RESPONSIBLE AGENCY
VA Commercial Fishing Law / Recreational Fishing Law	VA Code 28.2-100 – 1001	VA Marine Resources Comm. (VMRC)
VA Submerged Lands Law	VA Code 28.2-1200 – 1213	VMRC
VA Wetlands Act	VA Code 28.2-1300 – 1320	VMRC
VA Coastal Primary Sand Dune Act	VA Code 28.2-1400 – 1420	VMRC
VA Historic Resources Law	VA Code 10.1-2200 – 2216	VA Department of Historic Resources (VDHR)
VA Antiquities Act	VA C ode 10.1-2300 – 2306	VDHR
VA Endangered Species Act	VA Code 29.1-563 – 570	VA Department of Game & Inland Fisheries (VDGIF)
VA Fish & Wildlife Law	VA Code 29.1-100 et seq.	VDGIF
VA Endangered Plant & Insect Species Act	VA Code 3.1-1020 – 1030	VA Department of Agriculture and Consumer Services (VDACS)
VA Noxious Weed Law	VA Code 3.1-296.11 - 296.21	

Listing of State Natural Resource Laws (continued)

LEGISLATION	CITATION	RESPONSIBLE AGENCY
VA Chesapeake Bay Preservation Act	VA Code 10.1-2100 – 2115	Chesapeake Bay Local Assistance Dept. (CBLAD)
VA Water Quality Improvement Act of 1997	VA Code 10.1-2118 – 2128.B.	VDCR
VA Water Control Law	VA Code 62.1-44.2 - 44.34	VA Department of Environmental Quality (VDEQ)
VA Ground-water Management Act	VA Code 62.1-44.84 - 44.104	VDEQ
VA Environmental Quality Act	VA Code 10.1-1200 - 1221	VDEQ
VA Waste Management Act	VA Code 10.1-1400 - 1457	VDEQ
VA Open Space Land Act	VA Code 10.1-1700 - 1705	VA Outdoors Foundation (VOF)
VA Erosion & Sediment Act	VA Code 10.1-560 - 571	VDCR
VA Natural Area Preserves Act	VA Code 10.1-202 - 217	VDCR
VA Conservation Easement Act	VA Code 10.1-1009 - 1016	VDCR
VA Shoreline Erosion & Public Beach Law	VA Code 10.1-700 - 711	VDCR

Appendix D. Definition of the Term "Seasonal Pond"

Since heavy rainfall may create ephemeral pools of water in upland sites that support no wetland plant species or provide only insignificant wetland habitat for animal species, it is evident that a definition is needed to provide a "minimum standard", of sorts, for distinguishing between temporary wet places and seasonal pond wetlands. At the other end of the seasonal wetland spectrum, some areas have intermittent inlet or outlet streams, that for short periods may functionally connect a seasonal wetland to a permanent water body, and thereby confusing the issue further. After consultation among DCR-DNH ecologists and biologists, the following definition for the term "seasonal pond" was developed.

The Coastal Plain Seasonal Wetland communities referred to in this management plan as "seasonal ponds" at Colonial National Historical Park shall be defined in the following manner: Any natural depression wetland, whether geological in origin or of some other natural derivation, generally surrounded by forest, with a seasonally flooded to semipermanently flooded hydrologic regime isolated from a <u>perennially</u> flowing stream and supporting vegetation consisting of at least one obligate wetland indicator or a prevalence of facultative wetland indicators. A natural depression wetland that meets the above definition but which has an <u>intermittently</u> flowing inlet or outlet stream will also be considered a "seasonal pond". The wetland indicator status of a taxon will be that defined by the National Wetlands Inventory of the U.S. Fish and Wildlife Service (Reed 1986). [Some of the wetland plant species likely to be encountered in the seasonal ponds of Colonial National Historical Park are shown in Appendix E.] Further support for the isolated nature of these wetlands will be the presence of faunal components typically found in isolated wetlands, including but not limited to salamanders of the genus *Ambystoma* (*A. tigrinum*, *A. mabeei*, *A. opacum*), fairy shrimp (Anostraca), clam shrimp (Conchostraca), barking tree frog (*Hyla gratiosa*), and the comet darner (*Anax longipes*). Seasonal ponds that have experienced modification of the natural light regime due to alteration of the canopy within or adjacent to the wetland (field ponds) shall be considered as seasonal ponds for the purposes of this plan, so long as native species predominate.

Appendix E. Obligate and Facultative Wetland Plants Potentially Found in Seasonal Ponds at Colonial National Historical Park

(Based on those species documented in the nearby Grafton Ponds and the category assigned by the USFWS Wetland Plants of the State of Virginia 1986)
*rare according to DCR-DNH rare plant list

OBLIGATE (OBL) - Taxa always found in wetlands under natural conditions (frequency greater than 99%) but may persist in non-wetlands if planted or in wetlands that have been drained, filled, or otherwise transformed into non-wetlands.

Trees
Quercus lyrata

Shrubs
Cephalanthus occidentalis
Decodon verticillatus
Itea virginica
Litsea aestivalis *
Rhododendron viscosum
Viburnum nudum

Vines
Smilax laurifolia

Herbaceous
Azolla caroliniana
Carex bullata
Carex gigantea
Carex glaucescens
Carex joorii
Carex striata (formerly C. walteriana)
Chelone cuthbertii *
Dulichium arundinaceum
Eleocharis obtusa
Eleocharis tuberculosa
Eragrostis hypnoides
Hottonia inflata *
Juncus debilis
Juncus repens
Lindernia dubia
Ludwigia linearis
Ludwigia sphaerocarpa*
Myriophyllum pinnatum
Panicum rigidulum var. pubescens
Polygonum hydropiperoides
Pontederia cordata

Proserpinaca palustris

Obligate Herbaceous cont'd
Proserpinaca pectinata
Rhexia mariana
Rhexia virginica
Rhynchospora capitellata
Rhynchospora corniculata
Saccharum baldwinii
Sparganium americanum
Triadenum virginicum
Torreyochloa pallida (Puccinella pallida on USFWS list)
Utricularia biflora
Utricularia radiata -watchlist
Xyris jupicai

Ferns
Osmunda regalis var. spectabilis
Woodwardia virginica

FACULTATIVE WETLAND (FACW)
Taxa usually found in wetlands (67%-99% frequency), but occasionally found in nonwetlands.

+ indicates frequency of occurrence in wetlands is nearer the high end of scale shown above.
- indicates frequency of occurrence in wetlands is nearer the low end of the scale shown above

Trees
Aronia arbutifolia
Magnolia virginiana (+)
Quercus laurifolia (-)

Shrubs
Leucothoe racemosa
Lyonia ligustrina
Vaccinium corymbosum (-)

Herbaceous
Andropogon glomeratus
Bidens frondosa
Cyperus erythrorhizos (+)
Cyperus pseudovegetatus
Diodia virginiana
Echinochloa muricata (+)
Echinochloa walteri (+)
Eupatorium semiserratum
Juncus effusus
Listera australis
Oldenlandia uniflora
Panicum dichotomiflorum (-)
Panicum verrucosum
Rhynchospora inexpansa
Saccharum giganteum
Scirpus cyperinus (+)

Ferns
Osmunda cinnamomea
Woodwardia areaolata

Additional Wetland Species of Grafton Ponds with no agreement at Regional level or not included on USFWS list
Agalinis purpurea (Nat.= FACW)
Carex debilis (Nat. = FACW,OBL)
Dichanthelium longiligulatum (not on list)
Fimbristylis autumnalis (Nat. =FACW+, OBL)
Fimbristylis perpusilla (not on list)
Nyssa biflora (not on list)
Panicum rigidulum var. condensum (not on list)
Quercus nigra (Nat. = FAC, FACW)
Rhexia nashii (Nat. = OBL)
Riccia sp. (a liverwort)(not on list) - members of this genus characteristically grow in summer on soils that have flooded in spring
Sphagnum cuspidatum (not on list)
Sphagnum macrophyllum * (not on list)